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PRODUCT ENGINEERING

SEPTEMBER
1934

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In the development of machinery, the application of methods for detecting, measuring and analyzing vibrations carries the project beyond the status of mere imitation and establishes for the product new standards of perfection. SEE PAGE 322

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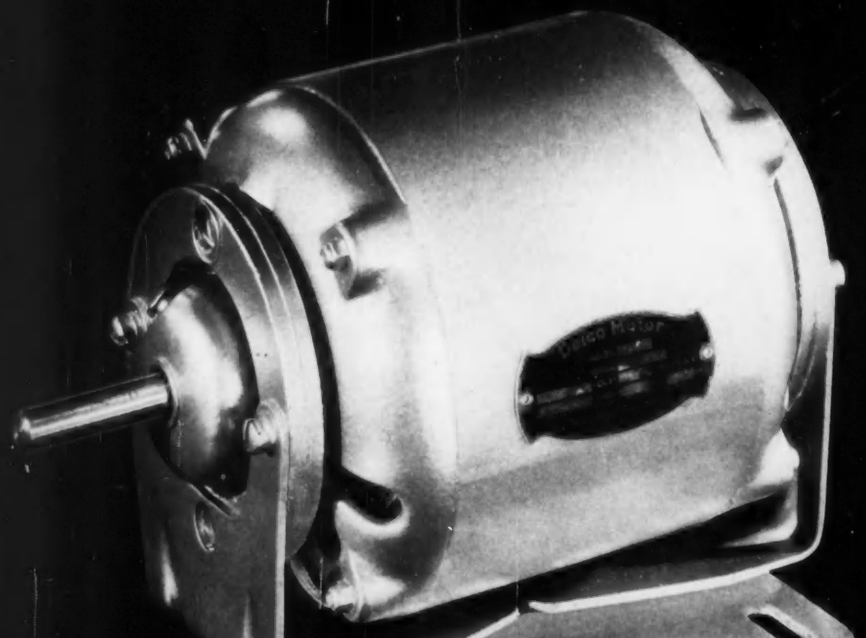
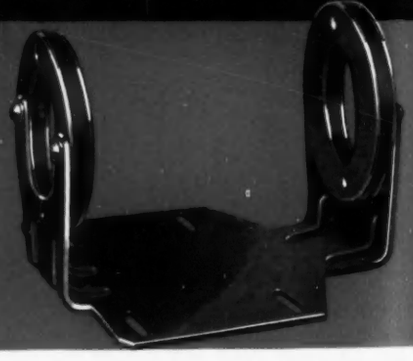
Mechanical Design • Product Development

McGRAW-HILL PUBLISHING COMPANY, INC.

Delco Motors



QUIET, too—because of Vulcanized Rubber Cradle Mounting . . . .



Quietness is essential in a household appliance motor. You can count on a Delco to give years of uninterrupted service—and, what is more, you can be sure that it will always operate quietly. Such quietness is partially due to proper balance and precision manufacture—but it is *doubly* assured by Delco's Vulcanized Rubber Cradle Mounting. In this construction the rubber ring is vulcanized between the steel plates and effectively absorbs all the objectionable motor vibration. The rubber is held permanently in place by being vulcanized to both plates. The quietness resulting from this feature is most appreciated in the second and third years of use—when the ordinary motor is apt to become noisy. This characteristic of Delco motors is just as highly desired by the manufacturer of household appliances as it is gratifying to the dealer and pleasing to the ultimate owner.

Delco Products Corporation · Dayton, Ohio

PRODUCT ENGINEERING

VOLUME 5 NUMBER 9

KENNETH H. CONDIT, *Editor* — MASON BRITTON, *Vice-President*
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LEONARD CHURCH, *Cleveland* — PAUL WOOTON, *Washington*
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October Number

The title of the lead article "Saving Money By Using Costly Alloys" sound paradoxical. But the author of the article proves it is true and shows what would happen if such alloys were not available.

"Cast Iron—The Dean of Engineering Materials" by J. M. Lessells is a timely restatement of some of the frequently ignored facts about this metal.

Too often the alibi for a failure is "The material's no good." But H. C. Berg, metallurgist of the Whitney Manufacturing Company, lists about 40 causes for failure and gives nine tests that will disclose the cause.

Other articles deal with die-castings versus stampings, steels for high temperature, design analysis, and electric motors.

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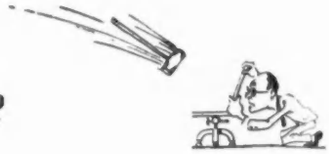
Intimate Correspondence



Agonized

PRODUCT ENGINEERING
NEW YORK

After the agonizing doses of alignment charts and debates in higher mathematics among the upper crust it is refreshing to know that there are still the spring tables in the handbooks to fall back upon.

I should say that if you want to get "in good" with a lot of fellows you might issue a "professors' supplement," and confine the mathematical mysteries to those who pretend to thrive on them. We all can't play 20 or more opponents at chess blindfolded.

Now if you want to please the other 99 per cent of your subscribers you might handily enlarge upon the tables mentioned above and include a nice smear of likely rectangular sections—and square, and some really simple, easily digested and above all useable information on torsion springs—tables again preferred.

If this is too much pure ozone for you—skip it, otherwise the tables are the thing.

J. D. LAWRENCE,
Conshohocken

IT'S a popular indoor sport to razz the college professors and brain trusters but situations do arise sometimes where the good old rule-of-thumb methods just don't apply. Then it's very handy to have a thinker or two around to help us out of our troubles.

Fortunately for our peace of mind, which has been rudely jarred by Mr. Lawrence's sarcastic comments, we have up our sleeves some tables that may come fairly close to his specifications.

Calling Montreal

PRODUCT ENGINEERING
NEW YORK

This is from another beggar, which I notice you deal with quite a few. Those articles you publish relating to machine design are extremely valuable to keep, but being only a reader of your magazine through the courtesy of my employers, I started to copy them—drawings, explanations, and all—but it takes quite a time to do as nice a job as yours. If some day you'll condense those articles in a book for selling, we wouldn't have to copy them and be sure to get something more practiical.

Among those articles, there are "Shifting Mechanisms," "Ball Bearing Arrangements," "Hinges and Pivots," etc.

V. TRUDEAU

SINCE Mr. Trudeau gave no other address than his home city we hope this meets his eye. Incidentally, when a subscription to *Product Engineering* costs only two dollars, why go to all the trouble of copying articles and drawings?

The chances are, however, that some of the articles he mentions will be combined in book form one of these days. A few more requests for them will hasten the day.

Answering "XYZ"

PRODUCT ENGINEERING
NEW YORK

Re "XYZ" letter, "Invention Clearing House," July issue.

Suggest he read "This Brave New World," by Aldous Huxley. (Published in Germany—suppressed in U.S.A., but not completely). "XYZ" will feel conservative indeed.

S. S. COLDWELL,
Milwaukee

SINCE we sometimes suspect that we are pretty conservative, too, perhaps we ought to see a bootlegger of books and get a copy. Will have more to say on this point if we succeed.

Clipper Comments

PRODUCT ENGINEERING
NEW YORK

I was at first more startled than surprised; and then much pleased. And now after several months a little disappointed.

Clippers have had their say in several issues on your "Intimate Correspondence" page, and the ideas set forth have most certainly struck home with me.

"Shot-Welded Stainless Steel" starts on an even numbered page;

"Cams for High Speeds" start on an even numbered page.

Oh, well! It is a lot to expect, and as you said, there are other things which enter into the story besides the Clippers.

I find that it is necessary for me to trim all pages down in size in order to get them to fit in a standard letter file. How about trimming the magazine to 8¾ by 11½—the same as the S.A.E. Journal and Automotive Industries, to mention only two? Isn't the A.S.M.E. Journal that size too?

Yes, we Clippers would appreciate the starting of good reference articles on the odd numbered pages for obvious reasons and I for one would like a little less trimming to do.

M. D. HANES,
Pontiac

HERE we have the old, old battle between the Clippers and the Appearance Hounds. We enlarged the page size and widened the margins to satisfy those who demanded a magazine that looked better and was easier to read. Not having heard that particular kind of squawk for some time, we apparently satisfied them.

Don't see just how we can reconcile the two camps on page size, but we can keep trying to start the reference material on the right hand page.

Likes Our Charts

PRODUCT ENGINEERING
NEW YORK

We would like very much to have you send us two (2) copies of the article "Charts for Obtaining Spring Dimensions Directly," which you published in the June, 1934, issue.

May I take this opportunity to congratulate you on the splendid work you are doing with this magazine? We have found it very interesting and helpful.

G. A. RICHROACH,
Brooklyn

EVIDENTLY those spring charts weren't so bad after all. At any rate, this is only one of many letters asking for extra copies. And the author of it thinks we are doing "splendid work." Well, well, the world isn't all hard knocks, after all.

Another One

PRODUCT ENGINEERING
NEW YORK

May I express my appreciation for *Product Engineering?* It fulfills the needs of progressive engineering better than any publication that I know of.

As you are interested in reader's interest, drum cams and design of helical gears and hydraulic drives are mentioned.

Will you please send the clipping, "Practical Data & Formulas for the Design of Worm Gears," which appeared in the February, 1934, issue?

I thank you for your interest and your publication.

D. A. GRIEB,
Indianapolis

MANY thanks for the suggestion on inclusion of articles on drum cams and hydraulic drives. We have a line on the cams but it will probably be some months before the article materializes. The author is one of these deliberate guys.

The hydraulic stuff is coming, however, and soon. We hope to print it this year.

PRODUCT ENGINEERING

KENNETH H. CONDIT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. SEPTEMBER 1934 VOLUME FIVE, NUMBER NINE

The School of Experience Is Always in Session

PRESSED for time in fulfilling the routine duties of a job, the engineer is likely to ignore the essential things necessary for a mastery of his profession. In the stress of developing a succession of new models or new designs, the product engineers are likely to forget that one of the controlling factors upon which depends success or failure is a broad knowledge of current progress and accomplishments.

In preparing for his career the engineer will pass a prescribed course at a technical school or college. He will study the laws of nature and how they can be applied for the benefit of mankind. Having obtained an average knowledge of mathematics, physics, chemistry and the applied sciences, he receives his degree and takes up his work in industry. Progress thereafter depends on the degree to which he can "cash in" on his knowledge of fundamentals.

It is unfortunate that many of our engineers seek to become "specialists." Having procured a job in some industry or other they immediately set about to learn all the details concerning that industry and their particular job, to the exclusion of everything else. It is surprising how quickly they dig themselves into a deep and narrow groove, from which escape is well nigh impossible. Too often they ignore or ridicule the products of their competitors and the developments taking place in other fields of engineering design.

He who scorns the accomplishments of his competitors and who fails to keep himself informed of the changes and progress in his profession will soon be out of the race. The wise designer will profit by the achievements, as well as the failures, of his competitors and keep himself informed of the changes and progress relating to his profession.

Education merely furnishes the tools with which to profit from experience. But one may profit equally as much from the experiences of others. As stated in a quotation appearing in the Hall of Science at the World's Fair, "The common experiences of normal people are the matters of science." Dr. Russell H. Conwell in his famous lecture, "Acres of Diamonds," demonstrated how again and again the apparently trivial experiences of those who failed in their search for fame and fortune were later turned into fabulous wealth by others who had an inquiring mind.

Likewise in engineering design, innumerable instances are known wherein common experiences furnished the basis for great developments. Boys playing marbles furnished the idea for toy lamp bulbs; the secret of the successful reaper was revealed to McCormick when his wife's spinning wheel fell over; when Watt saw steam issuing from a wash house the idea of the condensing steam engine flashed into his mind; the mechanism for automatically folding newspapers as they come off the press was adopted in textile machinery for folding sheeting.

Admittedly, the tremendous rate at which new developments are taking place makes it impossible to study every news and technical article in detail. This makes it all the more important to scrutinize carefully the items that do come to one's attention. The application of the experiences of others to your own problems are not always apparent. But the continuous adoption of new developments in one industry taken from another field of product design is positive evidence of the fact that what is good for the goose is good for the gander.

It is said that experience is the best teacher, though perhaps the most expensive one. But to profit from the experiences of others costs nothing. And their experiences are broadcast through the technical publications both in the editorial and the advertising pages. A thoughtful perusal of both may give the nucleus of an idea that might be developed into a profitable product.

Instruments and Methods

Of a Machine Tool Research Laboratory

HANS ERNST
and
MARIO MARTELLOTTI

Research Department
Cincinnati Milling Machine and
Cincinnati Grinders Incorporated

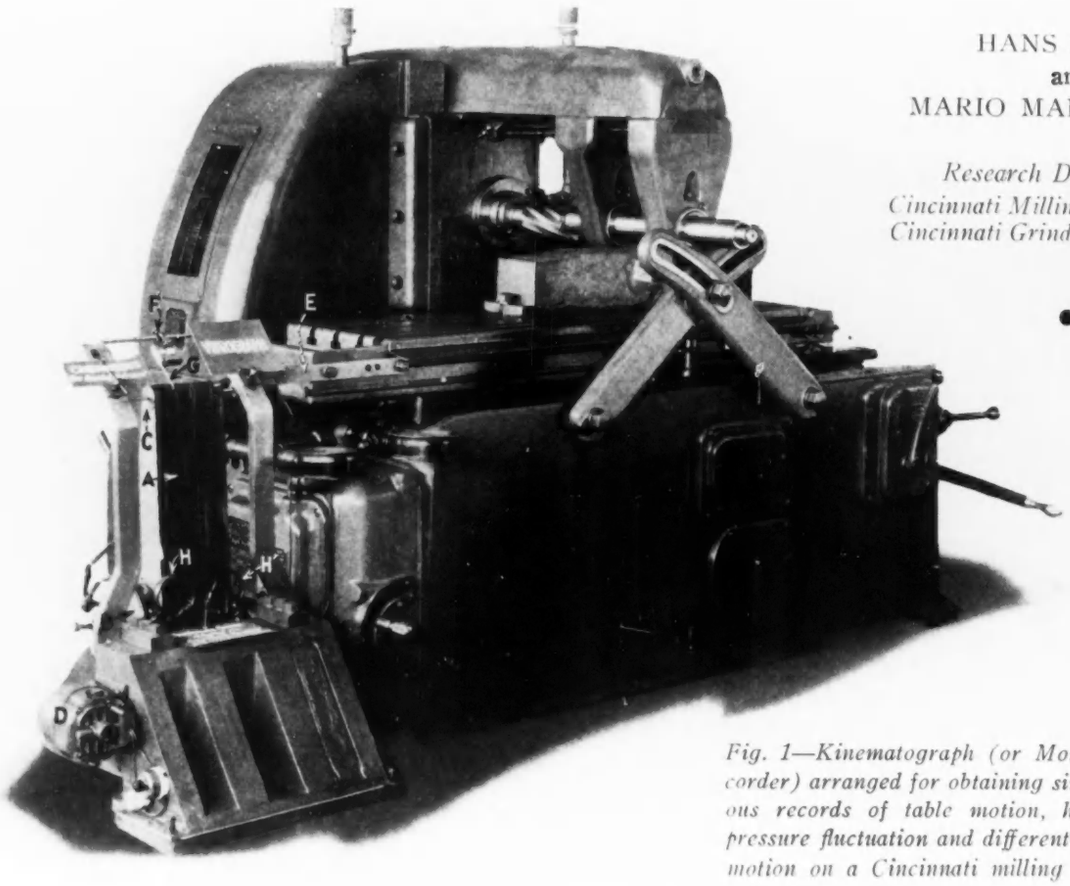


Fig. 1—Kinematograph (or Motion Recorder) arranged for obtaining simultaneous records of table motion, hydraulic pressure fluctuation and differential valve motion on a Cincinnati milling machine

THE development of modern, cost-reducing precision machine tools has brought many departures from traditional practice, among them the substitution of organized research and exact engineering knowledge for the empirical methods of the past. Today, the research laboratory has definitely found its place in the machine-tool industry, as it has in other industries where intricate machines are designed and built.

In all research laboratories much of the equipment used is of a highly special nature owing to the particular requirements of each class of work. Thus, in addition to standard instruments and devices which may be purchased, many appliances must be developed by the individual laboratory to meet the needs of each investigation. This is exemplified by the following description of some of the apparatus built, or modified, by the research laboratory of the Cincinnati Milling Machine Company, for use in the study and development of machine tools.

From a fundamental standpoint, any machine tool may be considered simply as a mechanical contrivance which provides relative motion between a piece of work and some form of cutting tool; thus in the development of machine tools, the study of motion, means for producing motion, and means for analyzing motion, all play a very important part. In certain cases, for instance, it is necessary to ascertain the degree of uniformity with which a slide or other machine part is moved, or the extent to which its movement is affected by forces encountered while in operation; in other cases the relative timing (or phase relation) of various motions or forces must be studied, in order to find the direction in which improvement may be effected.

The Kinematograph or Motion Recorder

In all cases where the speed of the motion to be investigated is not too great, or the sequence of motions is not too frequent, a direct graphic record may be made on

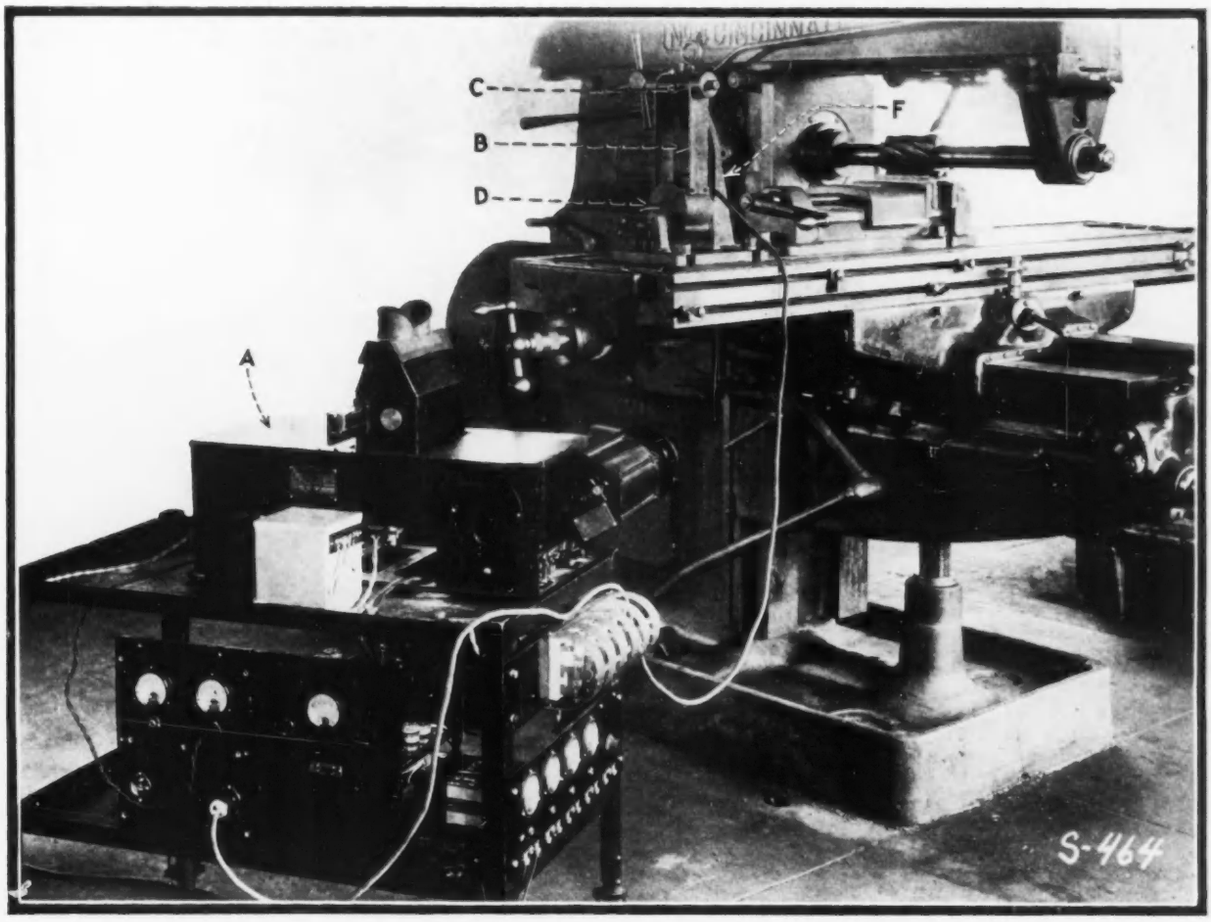


Fig. 2—Oscillograph with special vacuum tube amplifying system connected to accelerometer mounted on milling machine table

a moving cylinder or paper band by mechanical connections from the moving members. Such a device is generally known as a kinematograph. When used for the recording of low frequency vibrations, however, it is sometimes termed a vibrograph.

The mechanical arrangement of a kinematograph varies widely in accordance with the type of work upon which it is to be used, the type shown in the accompanying photograph, Fig. 1, having been developed originally for the study of the uniformity of table movement on milling machines, and the effect of various factors encountered under working conditions.

In milling machines of all types, the action of the cutting tool upon the work piece is not continuous, as in the case of a lathe, but consists of a rapid succession of tooth impacts. Thus, even with spiral milling cutters, where several teeth may be in contact with the work at one time, the force imposed by the cutter on the table (in the plane of its motion) is not constant but varies periodically with the entry and exit of each tooth. In a milling machine with mechanical feed, each increase in cutting force causes the table driving screw and its associated gearing to be stressed more highly and thus to yield a definite amount, only to rebound again as the cutting force decreases. By means of the kinematograph, the rate and amount of this rebound under various cutting conditions was readily ascertained.

In the form shown in Fig. 1, a band of smoked paper *A* passes over a pair of drums *B* and *C*, and is driven at a variable speed by the small motor *D*. The drums, motor and connecting gearing are mounted on a massive base so as to be relatively undisturbed by extraneous vibrations. The motion of the table is recorded on the smoked paper by a light, spring loaded stylus carried by the arm *E*. Since the movement of the stylus is in a direction perpendicular to the movement of the

So many mechanical, electrical and hydraulic elements are common to various types of machines that the means of analyzing them in any particular laboratory will be of value to all machinery designers

paper, any departure from uniformity is recorded by a change in the slope of the line. A precision chronograph is mounted at F so as to produce a simultaneous record of the passage of time by the marker G, the time between successive marks being adjustable to $\frac{1}{5}$ sec., $\frac{1}{2}$ sec. and 1 sec., as the requirements of the situation may demand.

In the application shown in Fig. 1 the kinematograph is arranged to record not only the motion of the milling-machine table, but also a number of other variables that affect its operation. The milling machine shown is a Cincinnati Hydromatic, in which the work table is moved by a hydraulic feeding system. In a milling machine with hydraulic feed, it is essential that the hydraulic circuit be so designed as to provide a proper control of the table motion under all operating conditions.

As already stated, the force imposed by the cutter on the table is not constant, but increases and decreases with the entry and exit of each succeeding cutting tooth; nevertheless, by a proper arrangement of the hydraulic circuit, a high degree of stability can be obtained without sacrificing the cushioning of successive tooth impacts, which is so largely responsible for the increased cutter life characteristic of machines with hydraulic feed.

In the case of the Hydromatic this stability is obtained by the use of what is known as the "locked circuit," in which the outflow from the cylinder is positively metered by a variable displacement pump, while the relation between the pressures in the two ends of the cylinder is governed by the operation of a special automatic differential valve. Under cutting conditions, therefore, it will be apparent that rapid fluctuations of pressure must be produced in both ends of the cylinder in order to meet the fluctuating loads imposed by the cutter.

Simultaneous Kinematograph Records

In the analysis of the action of the machine under various cutting conditions, and the effect of various forms of differential valves, the kinematograph was found to be a very great help. In addition to recording on the smoked paper the table motion and time as described, simultaneous records were made of the pressure changes in each end of the table actuating cylinder, and the motion of the differential valve. In order to record the pressures, the Bourdon gage elements H and H' were each provided with a flexibly mounted needle arranged to bear lightly on the smoked paper, and were connected by copper tubes to the two ends of the cylinder. The record of the differential valve movement was similarly made by a stylus attached to a rod connected directly to the stem of the valve.

With this apparatus many valuable records were obtained which helped materially in the development of the machine.

The Oscillograph

In many other problems encountered in machine-tool design and development, it is desirable to be able to obtain graphic records of force and motion changes occurring in extremely short intervals of time. This is particularly true in the study of all vibration phenomena, and also in the development of hydraulic circuits, and the study of cutting forces, where the fluctuations are too rapid to permit the use of any mechanical recording system such as used on the kinematograph described above. For all such investigations, it is customary to use some form of oscillograph in which the motion and force effects are recorded by beams of light moving across the surface of a rapidly moving photographic film.

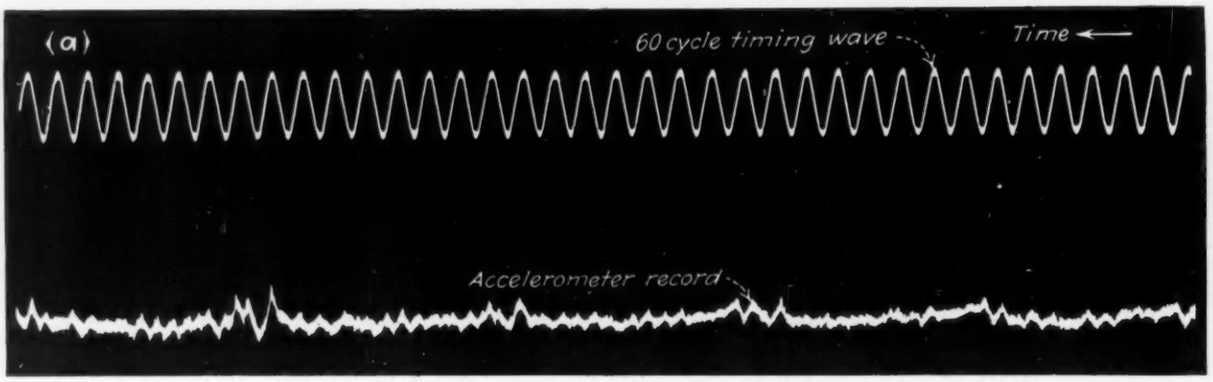


Fig. 3—Records made with accelerometer under chattering and non-chattering conditions. At (a) the

The oscillograph is well known in the electrical industries where it has been used in various forms for many years for recording variable currents and voltages. In mechanical industries, however (and particularly in the machine-tool industry), its application is more recent. This is partly due to the fact that, in the investigation of mechanical phenomena, it is generally necessary to use some form of primary instrument in order to convert a movement or force change into an electrical variation before it can be recorded on the oscillograph.

An application of the oscillograph to the study of "chatter" in milling machines is given in Fig. 2. Chatter is a condition of violent vibration between tool and work which is common in all classes of machine tools. It occurs in milling whenever some high harmonic of the tooth pressure curve synchronizes with the natural frequency of an important element of the machine or work supporting structure. When this hap-

pens, the pressure curve is itself modified so as to amplify and perpetuate a vibration at this frequency. Chatter frequencies commonly encountered range from 60 to 150 cycles per sec., the most destructive type being generally in the neighborhood of 90 cycles per sec.

In the photograph the oscillograph A is shown mounted on a light portable truck together with the auxiliary apparatus. The oscillograph itself consists primarily of three systems:

1. The string galvanometer elements which give deflections proportional to the instantaneous values of the currents received from the primary or generating systems.

2. The optical system by means of which beams of light are directed from a suitable source to tiny mirrors carried by the string galvanometers, and then reflected to, and focused upon, the recording apparatus.

3. The recording device, consisting of some form of photographic film carrier which is arranged so that the film may be moved at any desired constant speed in a direction perpendicular to the movement of the beams of light from the string galvanometers.

For visual observations, the photographic unit may be replaced by a rotating mirror system, or oscilloscope, which produces the appearance of a standing wave.

A Homemade Accelerometer

The primary instrument used in this particular application to transform the mechanical vibration of the table into an electrical vibration which can be recorded on the oscillograph, is a homemade device known as a pendulum type accelerometer. This device consists essentially of a heavy pendulum B, which is pivoted at C so as to be free to move in the plane in which the vibration is being investigated. Carried in the head of the pendulum is a large magnet coil D which is arranged for connection to a suitable source of electric current. A small fixed "pick-up" coil is carried by the stationary frame F and connected through a special vacuum-tube amplifying circuit with the oscillograph.

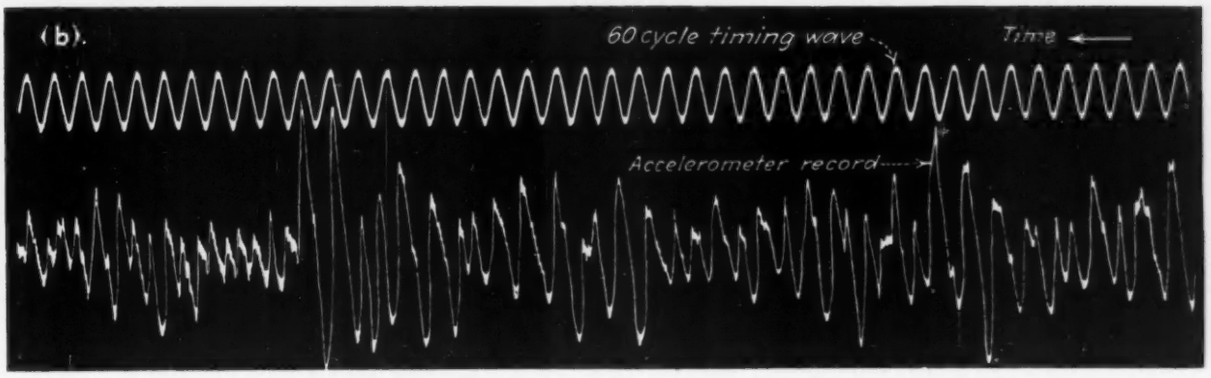
When the frame is vibrated from any source (as by the table of the milling machine in the case shown) the pendulum tends to remain stationary in space while the frame moves with respect to it. When relative motion occurs between the magnet D and the pick-up coil, however, an electromotive force will be induced in the latter, the instantaneous value of which will be proportional to the rate at which the magnetic field generated by the magnet is cut by the windings of the pick-up coil. Thus, where N equals the flux linked with the coil, the induced voltage E will be according to the relationship:

$$E = -\frac{dN}{dt}$$

But the rate of change of flux linkage depends, in this case, on the rate of relative movement taking place between the pick-up coil and the magnet D, and for small movements is directly proportional thereto.

The rate of relative movement between the pick-up coil and the magnet D will be:

$$\textit{Relative movement} = \frac{dx}{dt}$$



work was clamped securely to the table, at (b) the work was not clamped securely

The electromotive force induced in the pick-up coil will then be:

$$E = K\frac{dx}{dt}$$

The deflection of the string galvanometer element, however, will be proportional to the instantaneous value of E. Thus the slope at any point on the curve recorded on the oscillograph will be proportional to the instantaneous value of the acceleration of the frame relative to the pendulum.

$$\textit{Thus,}\ \frac{dE}{dt} = -\frac{d^2N}{dt^2} = K\frac{d^2x}{dt^2}$$

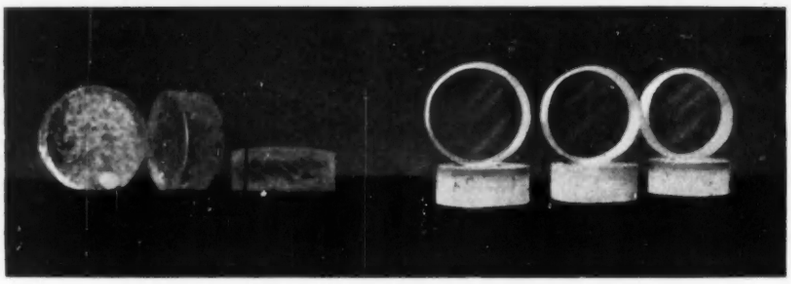
From a knowledge of the instantaneous value of the acceleration we can therefore also evaluate the instantaneous force.

This instrument is often used in a qualitative way for the comparison of different conditions. Thus, in Fig. 3, the record (a) was made when the work piece was not securely clamped to the table, while the record (b) was made with a securely clamped work piece. Comparison of these records shows the great reduction in the forces involved when the work was properly clamped, thus indicating the value of rigid work-supporting means.

(To be concluded in the October Number)

PRODUCT DEVELOPMENTS

• *Fused Quartz Windows*



Fused quartz disks 3-in. thick. Left, rough blanks and right, highly transparent finished product

In developing the design of the Bathysphere invented by Dr. Otis Barton for Dr. William Beebe's deep-sea explorations the major problem was not the design of the metal chamber. Rather, it was the design of the windows through which the deep-sea life at depths up to 3,000 ft. was to be observed and photographed. Glass of sufficient thickness to withstand the pressure of about 1,400 lb. per sq.in. at depths of 3,000 ft. would not be sufficiently transparent. Also, the relatively high coefficient of expansion of glass was another factor that made it impossible to use it.

Fused quartz has six to sixteen times the compressive strength of glass. It also has a low coefficient of expansion which permits it to be subjected to severe temperature changes without danger of cracking. And for equal thicknesses, clear fused quartz has a transparency much higher than that of any glass. With clear fused quartz windows much thinner than if made of glass, the required transparency would be obtained. But when fused in air innumerable gas bubbles are formed in the quartz, making it relatively opaque.

A process for obtaining large blocks of clear fused quartz was developed by the Thomson Research Laboratory of the General Electric Company at West Lynn, Mass. The method used is a result of years of experimenting by Prof. Elihu Thomson. Rock crystal of the highest quality obtainable is fused in a vacuum and while in the molten state is subjected to a high gas pressure. By fusing the material in a vacuum the number and size of the bubbles that are formed is greatly reduced and the gas in them is at an extremely low pressure. Many of the bubbles are evacuated spaces because of the condensation of the silica vapor which formed them at the high temperature of 1,800 deg. C. (about 3,275 deg. F.) which is required for fusing the quartz.

Before the mass of molten quartz starts to cool, the melting chamber is put under gas pressure. This either blots out the bubbles entirely or reduces them to a size that does not noticeably affect the transparency of fused quartz. Using this method three blanks for fused quartz windows 8 in. in diameter and 3 in. thick were made. And in spite of the manufacturing difficulties, these three blanks for the Bathysphere windows cost as little as $160 each, in the rough.

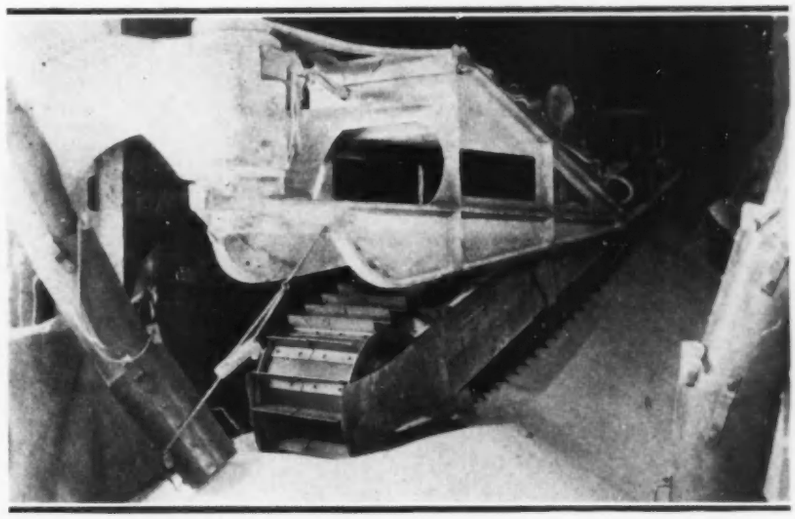
The second phase of the manufacture of these quartz windows was the grinding and polishing of the molded blanks. This was done by the A. D. Jones Optical Works, which specializes in work of this character. Extreme accuracy was required throughout all of the grinding and polishing operations in order to assure the required finished quality.

When mounted in the Bathysphere, the middle window is the only one used for visual observations and photographing. Powerful elec-

Beebe's Bathysphere for undersea observations at 3,000 ft. depth, showing the arrangement of the fused quartz windows

tric lamps are mounted at each of the two side windows, so arranged that the rays from the two lamps meet in front of the middle window briiliantly illuminating the objects within that region.

The sphere itself is 4-ft.-8½ in. outside diameter, made of cast steel. Watson-Stillman Company made the sphere and assembled the equipment.



Use of magnesium alloy castings made possible a light conveyor with a long overhang. Built by Stephens-Adamson Mfg. Co. for trimming box cars

• *Chrome-Moly Rods in High-Speed Diesels*

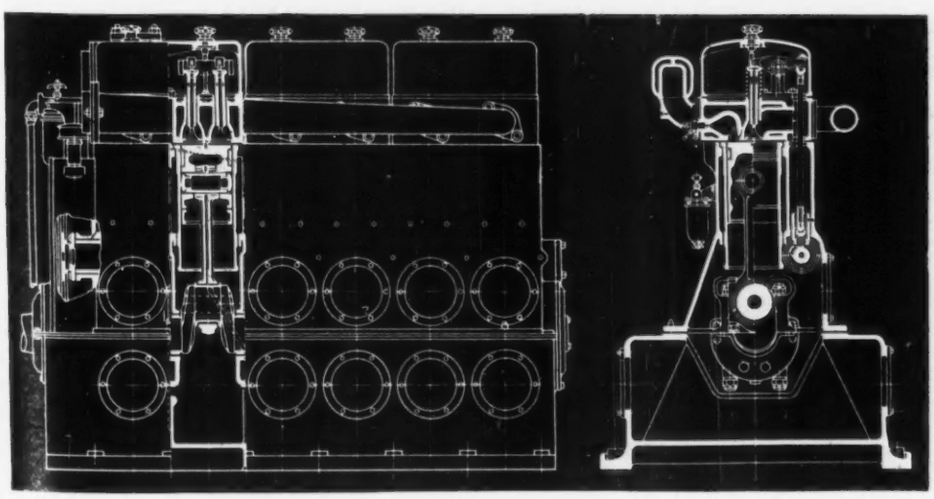
Weight limitations have compelled designers of diesel engines to go to higher speeds and higher-grade materials. Typical of this trend is the De La Vergne Type VL, 7x8 four-cycle, solid injection diesel engine, outline drawing of which is shown here. The auxiliary accompanying view shows a comparison of connecting rod sections when made of carbon steel versus chrome-molybdenum steel. Quoting W. L. H. Doyle, chief engineer of the De La Vergne Division of the Baldwin-Southwark Corporation:

"A rod made of carbon steel would not permit the same maximum speed as one made of alloy steel. Also the load on the bearings is less when the latter is used."

Other noteworthy features of this 200-hp. engine are aluminum oil pan, aluminum alloy heat-treated pistons, chrome-nickel alloy steel piston pins and camshaft, timing gears are upset forgings of nickel steel heat-treated and hardened, nickel cast iron cylinder heads, chrome-vanadium cylinder head studs, aluminum covers for cylinder heads and timing gears.

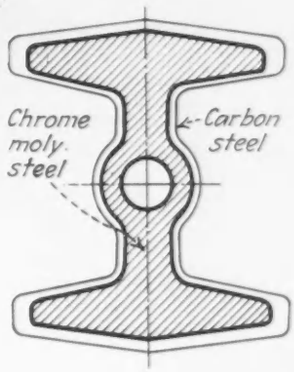
Through the intelligent use of high-grade materials the weight of this engine has been reduced to less than 21 lb. per b. hp.

Editor's Note—A complete analysis of the significance of high-grade materials in engines will be given in an article "Saving Money by Using Costly Metals" which will be published in the next number of *Product Engineering*.



Alloy steels and aluminum are used extensively in the De La Vergne 7x8 four-cycle solid injection diesel engine

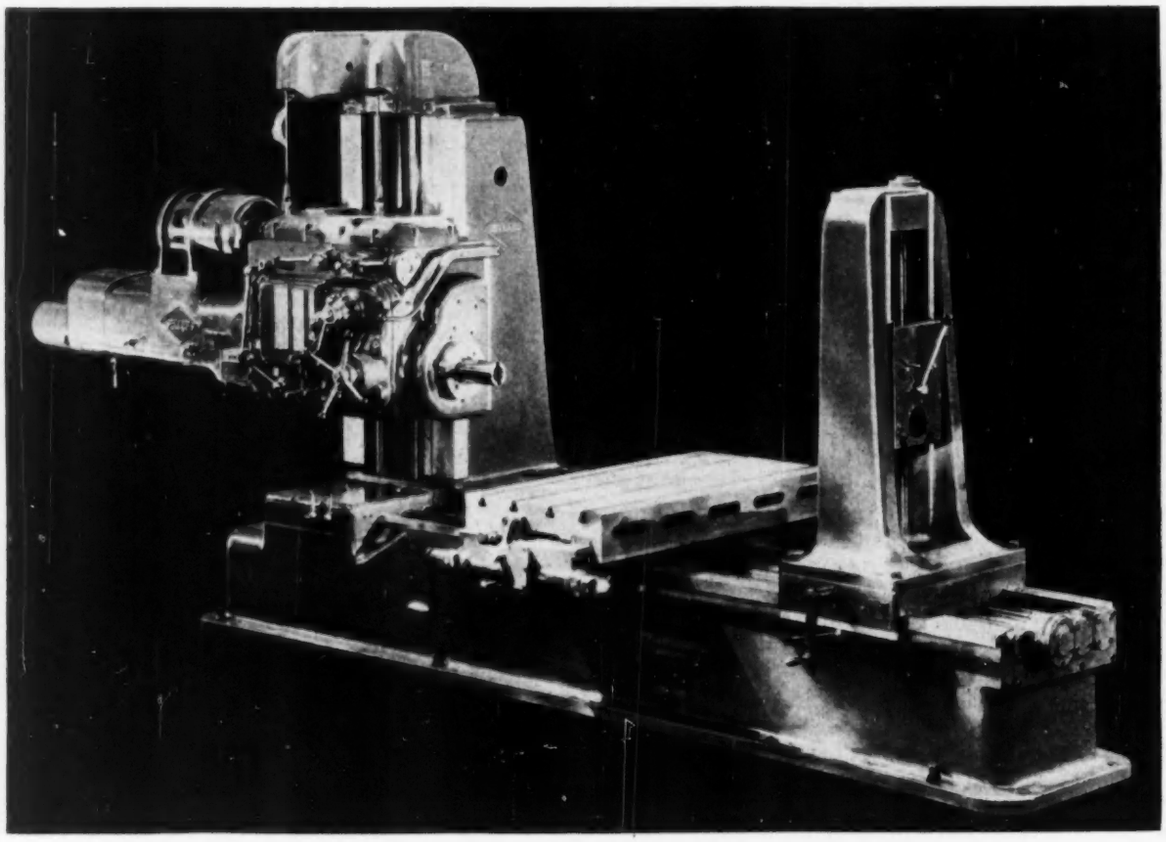
Comparison of connecting rod cross-sections using chrome-molybdenum steel and plain carbon steel



• *Magnesium Alloys for Conveyors*

To completely fill box cars with loose material such as silica sand, the box-car trimmer, shown in the accompanying illustration, must be able to reach through the door to all parts of the car. This makes necessary a long overhang on the conveyor support, making necessary light construction to avoid high stresses in the hinges.

By using magnesium alloy castings throughout, the weight of the overhung parts was reduced, making possible smaller sections. With lighter parts and lower bearing pressures on the hinge joints, the machine was much easier to handle.



Outstanding feature of this Sellers boring, drilling and milling machine is the "unit head" construction with built-in 10-hp. constant-speed motor which permits short shafts and a minimum number of gear contacts in drive to the spindle. Drive, feed and traverse mechanisms are in the head, permitting most convenient location of all control levers

• *Rubber-Tired V-Belt Drive Lawnmower*

Though slightly different in appearance lawnmowers have been for many years substantially the same in their design. Internal gears in cast-iron wheels drove an over-running pinion mounted on the shaft of the reel carrying the cutter blades. But advanced engineering is now revolutionizing all previous ideas of what a lawnmower should be.

In what they claim to be the last word in the design of lawnmowers, the engineers of Yard-Man, Inc., have developed a strikingly new machine that incorporates many of the modern developments in parts, materials and finishes.

To procure silent operation, the two 9-in. traction wheels have anti-skid rubber tires. Each wheel is grooved for a V-belt that drives a small pulley carried on an over-running clutch mounted on the shaft of the reel. To minimize friction, the wheels are mounted on Hyatt roller bearings and the reel shaft runs on dust-shielded annular ball bearings. This also eliminates the necessity of constant attention to lubrication.

A tubular cross bar with flange ends is used for the tiebar. Cutter bar adjustment is outside of the frame in order to be easily accessible.

All small parts of this lawnmower are rust-proofed by cadmium plating and finished in black enamel and silver paint.

• *Electric and Hydraulic Drives for New Grinder*

In the new Gleason No. 14 spiral bevel gear grinder a motor-driven hydraulic pump supplies the power for operating the chuck release, moving the work head into and out of operating position, clamping and releasing the work head, swinging the grinding wheel into dressing position, operating the dresser unit and clamping the wheel adjusting unit. A relief valve is set to give a constant pressure of 150 lb. per sq.in. in the line.

In addition to the 1-hp. motor driving the hydraulic pump, there is a 5-hp. standard ball bearing motor in the base for driving the wheel spindle through V-belts, spline shafts and angular spiral bevel gears; a 2-hp. vertical motor in the base coupled to the feed drive bracket containing the crank plate for giving the stroke to the wheel, the index cam and the drive to the feed cam; and ¼-hp. motor for driving the centrifugal water pump. Each motor has an individual start and stop push-button station, all interlocked with an emergency stop button for all motors.

The controls are also interlocked to make it impossible to start the motors except in the sequence of hydraulic-pump motor, wheel driving motor and then feed motor. Feed motor is stopped automatically upon completion of the grinding of a gear once around, a limit switch lighting a red light to indicate that the feed cam is in the proper place

for dressing. Another limit switch on the hydraulic cylinder that compresses the spring chuck prevents the feed motor from starting unless the gear is properly chucked.

A plugging limit switch stops the wheel spindle instantly when the stop button is pressed, so that an operator does not have to wait for the wheel to stop.

The entire drive with the exception of the work spindle is mounted on anti-friction bearings, the wheel spindle being mounted on precision pre-loaded ball bearings.

• *New Applications for Molded Plastics*

Adopting the production method used in the automobile industry, a number of shoe manufacturers are now installing conveyors for their production lines. The design of such conveyors presented a number of problems, particularly that of preventing injury to the shoes while in transit and while being put on or taken off the conveyors. For such purposes, paddings and coverings would have been unsatisfactory because of their limited durability.

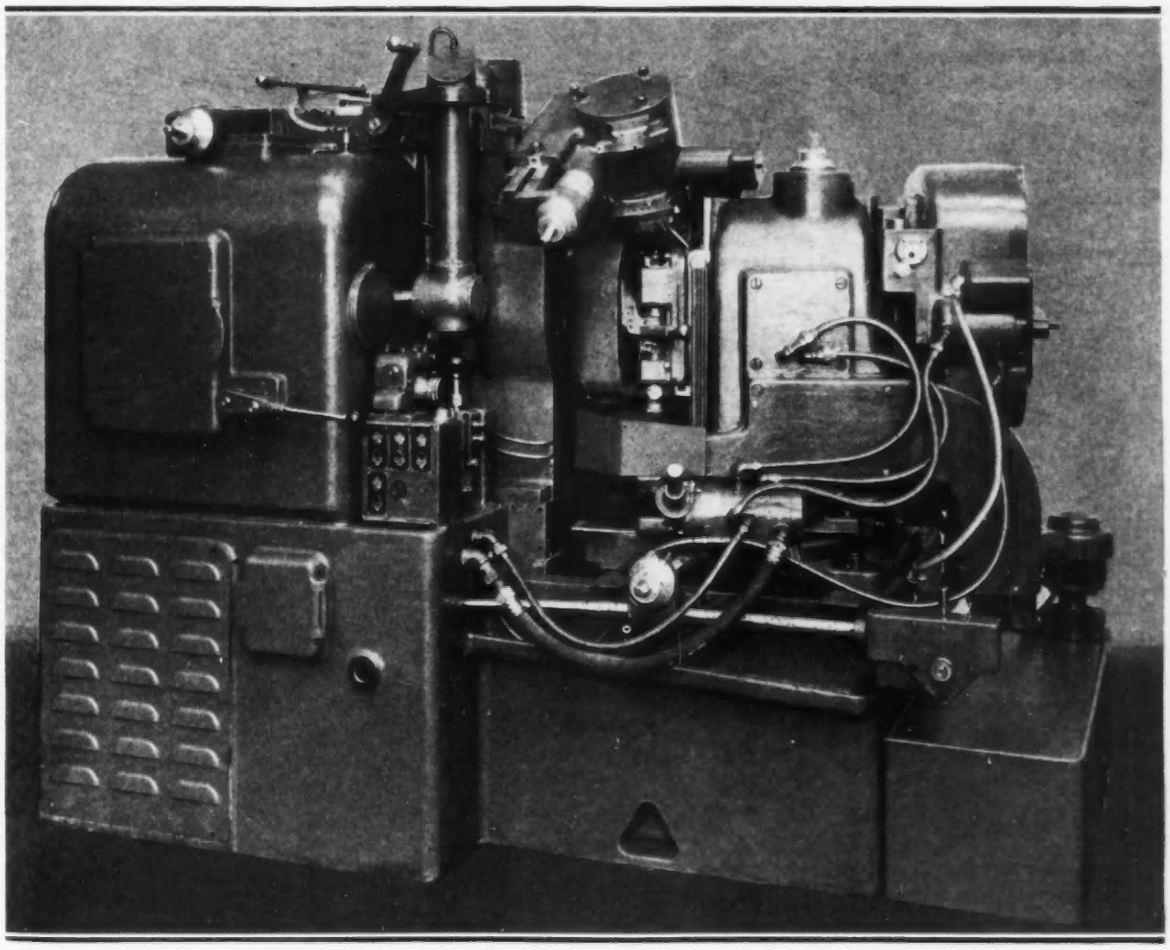
In the development of these conveyor systems by the Lamson Company, numerous tests were made to find a material that would have the necessary characteristics to be suitable for various parts of shoe conveying equipment. As a result of their experiments, bakelite was adopted for those parts that come in direct contact with the shoes, this material having the advantages of low cost, light-weight, inherently smooth finish and great durability.

In addition to parts coming in direct contact with the shoes some of the machine parts, such as cams, are also made of molded bakelite.

Molded plastic reinforced with metal inserts is used for the combination "Test-Lite and Fuse Puller" made by the Ideal Commutator Dresser Company. In appearance the device is similar to a pair of pliers. The test lamp is housed in the handle and the test pins project from the ends of the handle.

• *Aluminum for Riveters*

Heat-treated aluminum alloy castings are used for the yoke frames, end cover, pistons and cylinder heads of an air-pressure squeeze riveter designed by the Chicago Pneumatic Tool Company. On the yoke frame castings of their 20-capacity, 230-lb. size riveter, 57 lb. dead weight was saved by the use of aluminum.



With the new Gleason No. 14 spiral bevel and hypoid gear grinder, the wheel is fed into the gear until the full depth postion is reached. The wheel is then withdrawn and the gear indexed, alternate grinding and indexing proceeding until all the teeth have been ground

Design of End Connections For Round Rod Braces

With conventional methods of drafting it is difficult to avoid errors in designing rod braces. The method shown here simplifies the design problem, reducing cost of tools and forming dies

STUART D. POOL
Mason City, Iowa

IN THE manufacture of round rod braces with ends forged for through-bolts, die expense usually is the largest single item of cost. Consequently, considerable saving in cost is obtained by designing the rods so that the ends can be forged easily with simple, inexpensive tools, particularly when a number of different rods are needed. Likewise, a reduction in tool investment is possible when the design allows the same tools to be used for all rods made from the same size of stock. But the braces must satisfy the requirements of strength and stiffness regardless of the design method used.

Conventional drafting methods are responsible for the greatest source of unnecessary expense in designing round rod braces. A simple, easily forged brace will not be produced using only conventional 90 deg. views. But the drafting method described here not only produces easily manufactured braces meeting requirements of strength and stiffness, but also simplifies the design problem.

Where the ends of the rod are bolted to parallel planes of the structure, the ends are in line with the centerline of the stock, and the bending lines are perpendicular to the centerline of the stock. In such designs it is possible to use conventional methods to design braces so that the ends will be in line with the stock.

But where the surfaces to which the rod ends are attached are not parallel, at least one end of the braces will be distorted as shown in Fig. 1. The tension in such a brace will not be transmitted to the retaining bolt in a straight line, but eccentrically through the offset. This introduces an appreciable bending moment and means that the load the brace can carry is limited by both the strength of the section and the stiffness of the end connection.

In the following design, the brace differs from the conventional type in two respects. First, the breaking points are at the center of the stock rather than at intersections of lines along the stock. Second, the angle between the two bending lines of the ends may be any angle rather than the usual 0 or 90 deg. These two departures from the usual procedure minimize eccentric loading, and at the same time make it possible to use the same die equipment for forming any brace made from one size of stock.

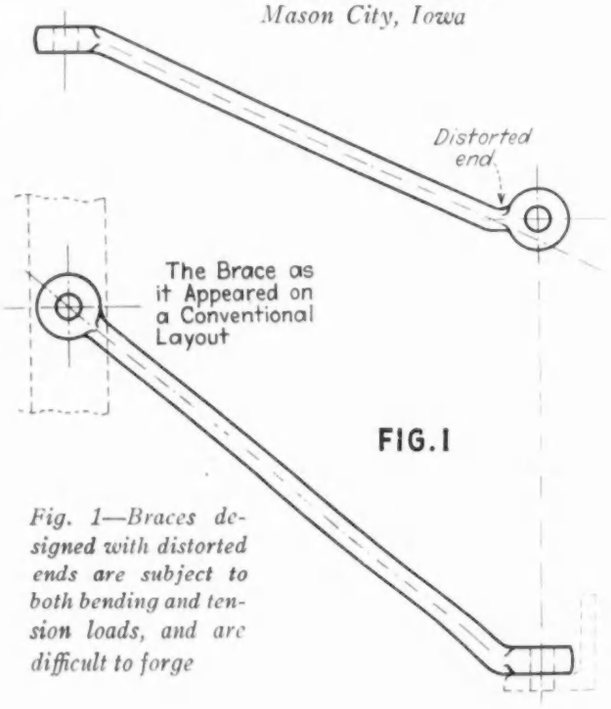


Fig. 1—Braces designed with distorted ends are subject to both bending and tension loads, and are difficult to forge

Die expense for different designs is reduced when the design uses the intersection of the stock and head centerlines as the breaking point. The distance from the center of the head to the breaking point then can be standardized at twice the diameter of the stock. With the breaking point at the center of the stock, the length of the blank between head centers is the same regardless of the angles to which the heads are bent.

The design of tools and dies for bending the heads to the proper angle presents no problem, because the heads can be forged to any angle with respect to each other by the aid of a rest and an adjustable quadrant.

In detailing this type of brace, two views are selected such that one true view of the top of the head will appear in each view. Referring to Fig. 2 a line is drawn parallel to the abutting surface of one end that is to appear as a side view. This line is drawn at a distance of $D/2$ from the abutting surface and serves as a centerline for the side view of the head. From the bolt hole, a distance of $2D$ is laid out along the center line and the point is projected into the top view. From the point where this projected line intersects the rod centerline, a line is drawn to the centerline of the bolt hole. On this line, and the rod centerline the view of the brace is constructed, using the same procedure for both ends of the brace.

To determine L, the length of the brace, a true view is turned up perpendicular to the stock of the brace as it appears in either view. This true view also gives the angle to which one end of the stock is bent. The angle that the other end makes with the shaft is determined by turning up a view perpendicular to the stock as it appears in the other view of the brace, or it can be found by any of the familiar short cuts.

The angle between the planes of the ends is determined, as shown in Fig. 2, by swinging an arc of any radius R about the breaking points in both views. Through these breaking points, lines M-M' and N-N' are constructed perpendicular to the stock, and of sufficient length so that they intersect the arcs. These lines are projected upon a coplanar circle of radius R, the angle between the projected lines being the required angle.

In order to project these lines (N-N' and M-M') upon a common circle, one of the lines is first projected into the other view of the brace. As shown in Fig. 2, the points M and M' are projected until they appear in the side view of the head, intersecting the centerline of the head. These two intersections are then projected, in line with the shaft, to intersect the circle of radius R constructed on the centerline of the shaft. Connecting the intersections forms M-M' in its projected view.

The line N-N' is projected parallel to the shaft and appears on the circle as a diameter, perpendicular to the center line of the stock. The angle between the projected views of N-N' and M-M' is the required angle. These lines represent the angular difference in bending lines, looking down the axis of the brace.

In manufacturing the conventional brace, the ends are readily upset and flattened but the required angle of bend is difficult to obtain without a board drawing or a special die for each design. With the new brace having the entire bend in but one plane, only a vertical jaw vise fitted with a horizontal bending quadrant is needed. By adjusting the distance between the bending quadrant and the edge of the vise jaws, the same bending tool can be used for any size of stock. Fixtures for drilling and punching the bolt holes are likewise simplified since the bend is in but one plane.

Where the quantity of braces justifies a special forming press, the flattening and bending operations can be combined. In using the improved brace design, any size of stock or angle of bend can be obtained from one press by using an adjustable stroke and a bending clamp with a quick-clamping fixture attached to the front of the press.

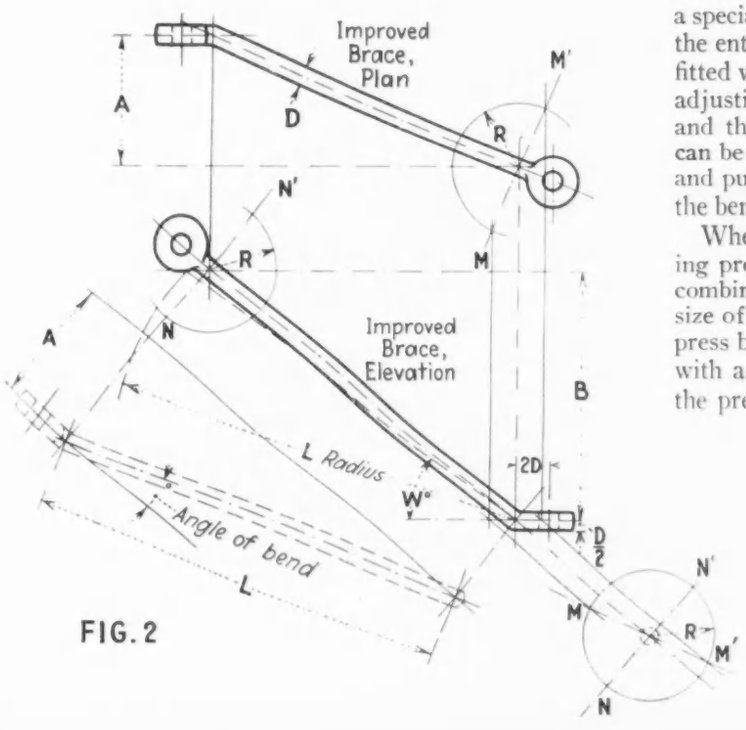
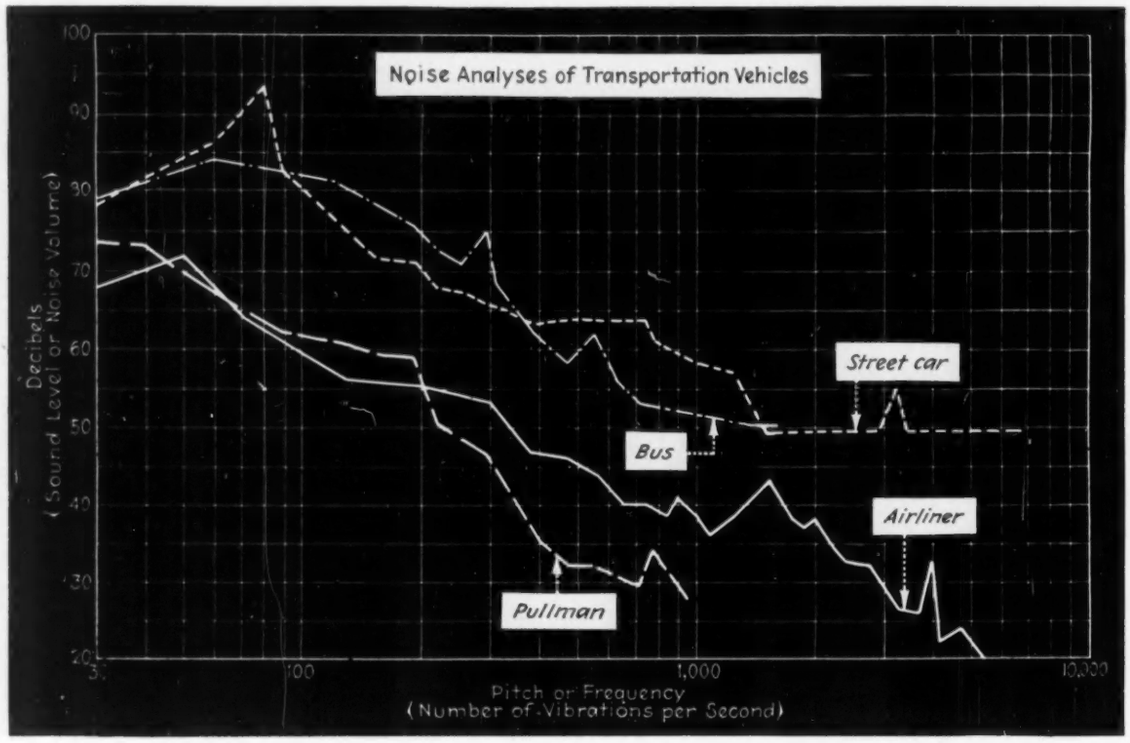


FIG. 2

Fig. 2—Each of the two views shows a side view of one head, the angle between their planes being given by the intersection of the lines M-M' and N-N' in the coplanar circle

NOVEMBER NUMBER

Summarizing progress that has been made during the past year in the improvement of parts, materials and finishes, and how product engineers are selecting them and using them in the design of profitable products that cater to the preferences, pride and purse of the purchaser



Analyzer For Tracing Sources of Noise

ONE of the vexing problems encountered in the elimination of noise arises from the fact that two sounds of equal loudness do not affect the human ear in the same manner. A sound having a lower frequency will have a greater intensity at its source and will exert greater pressure on the ear drum. For example, on a piano the note *C*, two octaves below middle *C* will emit 90,000 times as much energy and exert 300 times as much pressure on the ear drum as the note *C* two octaves above middle *C*, both notes being of equal loudness. It is for such a reason that the measurement of loudness alone does not solve the noise elimination problem.

A new portable instrument known as a noise analyzer was recently developed by W. O. Osbon, Westinghouse research engineer. This instrument analyzes the noise, separating it into the different elements of which it is composed and measuring the pitch and intensity of each component.

This instrument makes possible graphical analyses of the noises. Knowing the frequencies of the undesirable noises, the designing engineer is able to trace more readily the source of the noise and thereby concentrate all of his efforts toward the elimination of the most undesirable ones.

Total loudness readings obtained from this instrument check the findings of other investigations. The accompanying chart gives the noise analyses of four vehicles: (1) a conventional low-floor type of Pittsburgh Railways Company street car; (2) a Fageol Twin Coach of the Pittsburgh Motor Coach Company; (3) a GA-43 airliner of the General Aviation Manufacturing Corporation; and (4) a Pullman parlor car on a Pennsylvania Railroad train. The chart shows that in each of the four vehicles the low frequency sources of noise are much more intense than the high frequency sources. For the bus and street car, the higher sound levels in the high frequency range are attributed to the high frequency gear noises in the street car and to window rattle and similar impact noises in the bus.

Relative Noises in Transportation Vehicles

Media	Speed m.p.h.	Loudness in Decibels	
		Min.	Max.
Railroad Pullman	45	68	74
DeLuxe Transcontinental Bus	40	74	79
Railroad Coach	35	75	80
Transport Airliner*	190	77	81
City Bus	30	78	84
Street Car special gears	35	81	83
Street Car conventional type**	35	85	88

* Unfinished plane, sound insulation incomplete.
** Experimental car, helical cut gears.

Cams for High Speeds—III

In this concluding article the author gives tables of cam throw for various types of cams. For the preceding installments, see the July and August numbers

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Chief Engineer, The Universal Match Corporation

NOT only must the designer calculate and lay out the cam, but he must also have the drawings made so that the cam can readily be cut in the shop. Therefore the shop drawing should specify the milling cutter to be used, and working tables should be furnished to the shop so that the setting of the milling machine table can be determined quickly.

Tables for Cam Throw

All formulas for the cam throw really represent the movement of the axis of a cam follower, therefore, for cutting a cam on a milling machine it is better to use milling cutters having the same dimensions as a cam follower, as an end mill of the same diameter or a convex cutter with a profile having the same diameter as of the cam follower.

It is possible to consider the data received from the formulas for the throw as representing the variation of the cam radius, only in case, when the minimum radius of the cam is sufficiently large in comparison with the throw of the cam and with the radius of the cam follower, or in other words, when the radius of the cam follower is considerably smaller than the instantaneous radii of the cam surface of the working period of the cam.

For cutting a cam on a milling machine it is necessary to divide the working part of the came into equal spaces. Then the table should show for each division the decrease of the distance from the cutting tool to the center of the cam.

It is also advisable to add to each table a column showing differentials in length of two adjacent radii, so that the operator can find in the table the amount which the machine table should be raised after each cutting operation. These differentials should be shown on the working table only, and they should be expressed in linear measures, for instances, in thousandths of an inch. The table in general form does not require the calculation of the differentials.

In all equations for the cam throw the variable is represented by a ratio, in other words, for any point of the working period of the cam the variable represents either a fractional part of the whole working period of the cam (see Equations (7) and (11) for sine curve cam and Scotch Yoke cam respectively), or a fraction of a certain part of it (see Equations (32), (34), (36), (38), (40) and (42) for "Trapeze" cam).

Therefore, the tables for the cam throw can be made independent of the number of degrees in the working periods, making it possible to use one table for quite a number of cams with different working periods. The only requirement is that after dividing the working period of the cam expressed in degrees into the same number of equal parts as was used in making the table the resulting figures should be convenient for use on the dividing head.

For instance, the table is made for a cam with working period divided into forty equal parts; the proposed cam creates a movement during 120 deg.; then each step in the table corresponds to 3 deg. on the cam, and a dividing head can give conveniently 120 divisions per circumference.

By preparing beforehand a few tables with different numbers of divisions, it is possible to calculate quickly the throw for cams with different working periods. For example, three tables with 30, 36 and 40 divisions can be used for a very large number of cams with different working periods in degrees.

As it was done with basic formulas, all necessary steps for making a table for the cam throw are given for one type of a cam as in Table II and for the other types of cams only the final figures are given, as in Table IV.

Equation (7) gives the variation of cam radius S for a cam with sine curve acceleration, as:

$$S = F\left(x - \frac{\sin 360x}{2\pi}\right)$$

In this equation F is maximum throw of the cam or maximum variation of the cam radius.

The table should be made for the ratio S/F expressing the variation of the cam radius as fractions

Table II—Tabular Method for Calculating the Throw of the "Sine Curve" Cam

No. of α Divisions	0	1	2	3	4	5	6	7	8	9	10
360 x deg.	0	9	18	27	36	45	54	63	72	81	90
Sine 360 x deg.	.000	.156435	.309017	.453991	.587785	.707107	.809017	.891007	.951057	.987688	1.000
Sine 360 x deg. / 2π	.000	.024897	.049182	.072255	.093549	.11254	.12876	.14181	.15137	.15719	.15915
x	.000	.025000	.050000	.075000	.100000	.12500	.15000	.17500	.20000	.22500	.25000
$\frac{S}{F} = x - \frac{\text{Sine } 360\,x \text{ deg.}}{2\pi}$	.000	.000103	.000818	.002745	.006451	.01246	.02124	.03319	.04863	.06781	.09084
No. of α Divisions	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
360 x deg.	99	108	117	126	135	144	153	162	171	180	189
Sine 360 x deg.	.987688	.951057	.891007	.809017	.707107	.587785	.453991	.309017	.156435	.000	—.156435
Sine 360 x deg. / 2π	.15719	.15137	.14181	.12876	.11254	.09355	.07225	.04918	.02490	.000	—.02490
x	.27500	.30000	.32500	.35000	.37500	.40000	.42500	.45000	.47500	.50000	.52500
$\frac{S}{F} = x - \frac{\text{Sine } 360\,x \text{ deg.}}{2\pi}$	.11781	.14863	.18319	.22124	.26246	.30645	.35275	.40082	.45010	.50000	.54990
No. of α Divisions	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
360 x deg.	198	207	216	225	234	243	252	261	270	279	288
Sine 360 x deg.	—.309017	—.453991	—.587785	—.707107	—.809017	—.891007	—.951057	—.987688	—1.000	—.987688	—.951057
Sine 360 x deg. / 2π	—.04918	—.07225	—.09355	—.11254	—.12876	—.14181	—.15137	—.15719	—.15915	—.15719	—.15137
x	.55000	.57500	.60000	.62500	.65000	.67500	.70000	.72500	.75000	.77500	.80000
$\frac{S}{F} = x - \frac{\text{Sine } 360\,x \text{ deg.}}{2\pi}$	.59918	.64725	.69355	.73754	.77876	.81681	.85137	.88219	.90916	.93219	.95137
No. of α Divisions	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**			
360 x deg.	297	306	315	324	333	342	351	360			
Sine 360 x deg.	—.891007	—.809017	—.707107	—.587785	—.453991	—.309017	—.156435	.000000			
Sine 360 x deg. / 2π	—.14181	—.12876	—.11254	—.093549	—.072255	—.049182	—.024897	.000000			
x	.82500	.85000	.87500	.900000	.925000	.950000	.975000	1.000000			
$\frac{S}{F} = x - \frac{\text{Sine } 360\,x \text{ deg.}}{2\pi}$	.96681	.97876	.98754	.993549	.997255	.999182	.999897	1.0000			

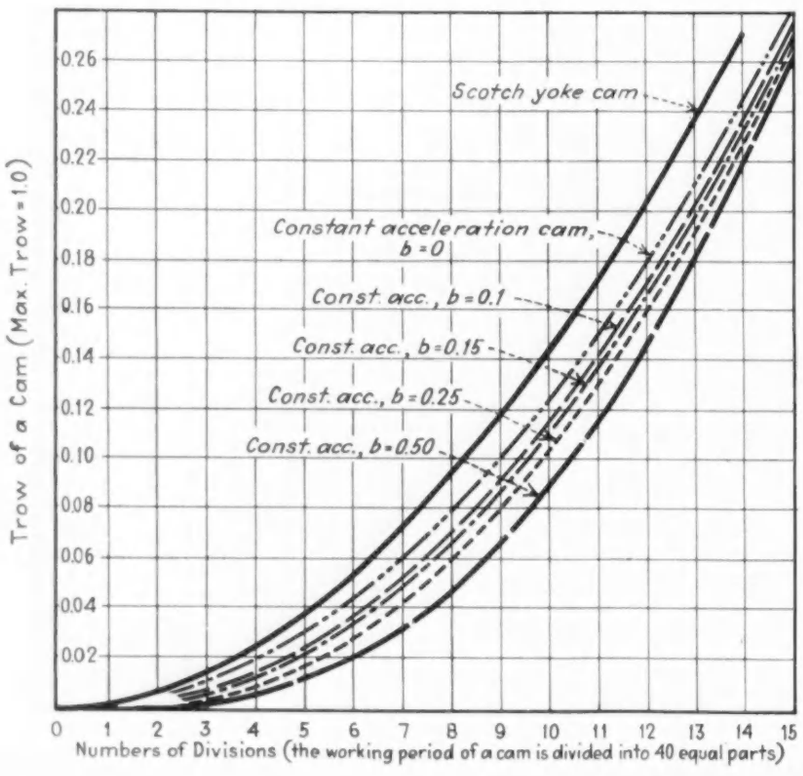


Fig. 12—Curves showing the difference in cam throw for the various types of cams listed in Table IV

Table III

Value of $\frac{\text{Max. Acceleration}}{F\,(360/\alpha)^2\,N^2}$	
"Sine Curve" Cam	6.283
"Trapeze" Cam, $b = 0.50$	6.283
"Trapeze" Cam, $b = 0.25$	4.888
"Trapeze" Cam, $b = 0.15$	4.489
"Trapeze" Cam, $b = 0.10$	4.314
"Trapeze" Cam, $b = 0.00$	4.000
Constant Acceleration Cam	4.000
"Scotch Yoke" Cam	4.935

N = speed of cam, rev. per sec.
α = working period in deg.
F = max. throw in inches.
Maximum acceleration will be expressed in in. per sec. per sec.

Table IV—Cam Throws

All cams are symmetrical, that is, the period of acceleration is equal to the period of deceleration. Thus for "Trapeze" cams $\varphi = 1$

Number of α Divisions	VALUE OF S/F					
	"Sine Curve" Cam or "Trapeze" Cam *with* $b = 0.5$	"Trapeze" Cam *with* $b = .25$	"Trapeze" Cam *with* $b = .15$	"Trapeze" Cam *with* $b = .1$	"Const. Accel." Cam or "Trapeze" Cam *with* $b = .0$	"Scotch Yoke" Cam
0	.000000	.000000	.000000	.000000	.00000	.000000
1	.000103	.000159	.000242	.000342	.00125	.001541
2	.000818	.001255	.001854	.002495	.00500	.006156
3	.002745	.004131	.005842	.007276	.01125	.013815
4	.006451	.009459	.012604	.014752	.02000	.024472
5	.01246	.017669	.022172	.024924	.03125	.038060
6	.02124	.028921	.034545	.037793	.04500	.054497
7	.03319	.043228	.049725	.053357	.06125	.073680
8	.04863	.060591	.067710	.071617	.08000	.09549
9	.06781	.081008	.088501	.092573	.10125	.11980
10	.09084	.104480	.112098	.116225	.12500	.14645
11	.11781	.131008	.138501	.142573	.15125	.17528
12	.14863	.160590	.167710	.171617	.18000	.20611
13	.18319	.193228	.199724	.203357	.21125	.23875
14	.22124	.228921	.234545	.237793	.24500	.27300
15	.26246	.267669	.272171	.274925	.28125	.30866
16	.30645	.309459	.312604	.314752	.32000	.34549
17	.35275	.354132	.355842	.357276	.36125	.38328
18	.40082	.401255	.401854	.402495	.40500	.42178
19	.45010	.450159	.450242	.450342	.45125	.46077
20	.50000	.500000	.500000	.500000	.50000	.50000
21	.54990	.549841	.549758	.549658	.54875	.53923
22	.59918	.598745	.598146	.597505	.59500	.57822
23	.64725	.645868	.644158	.642724	.63875	.61672
24	.69355	.690541	.687396	.685248	.68000	.65451
25	.73754	.732331	.727829	.725075	.71875	.69134
26	.77876	.771079	.765455	.762207	.75500	.72700
27	.81681	.806772	.800276	.796643	.78875	.76125
28	.85137	.839410	.832290	.828383	.82000	.79389
29	.88219	.868992	.861499	.857427	.84875	.82472
30	.90916	.895520	.887902	.883775	.87500	.85355
31	.93219	.918992	.911499	.907427	.89875	.88020
32	.95137	.939409	.932290	.928383	.92000	.90451
33	.96681	.956772	.950275	.946643	.93875	.926320
34	.97876	.971079	.965455	.962207	.95500	.945503
35	.98754	.982331	.977828	.975076	.96875	.961940
36	.993549	.990541	.987396	.985248	.98000	.975528
37	.997255	.995869	.994158	.992724	.98875	.986185
38	.999182	.998745	.998146	.997505	.99500	.993844
39	.999897	.999841	.999758	.999658	.99875	.998459
40	1.000000	1.000000	1.000000	1.000000	1.00000	1.000000

of the total throw, consequently the table can be used for any throw by simply multiplying the data by the cam throw.

Suppose the table is made for 40 subdivisions. The variable x changes from 0 to 1; meaning that the difference in the value of x in two adjacent columns of the table is equal $1/40 = 0.025$ and the change of the expression $360x$ deg. from one column to another is equal 360 deg. x $1/40 = 9$ deg. The table is self-explanatory.

Similar calculations are made for Scotch Yoke cam, constant acceleration cam and three Trapeze cams with different b values.

The results are compiled in Table IV and in Table III are given the comparative values of maximum acceleration for the different types of cams.

Fig. 12 shows graphically the difference in cam throws for the different types of cams represented in Table IV above, showing clearly that during the beginning of the movement the difference between the throws of these cams is very small, but nevertheless it has a great influence on the performance of the cam.

In all examples of Trapeze Cams, ϕ was selected it has a great influence on the performance of the cam. were analyzed. But if it is necessary to decrease the maximum acceleration or the maximum deceleration it will be worth the time spent to check up the possibilities of the use of ϕ smaller or larger than unity.

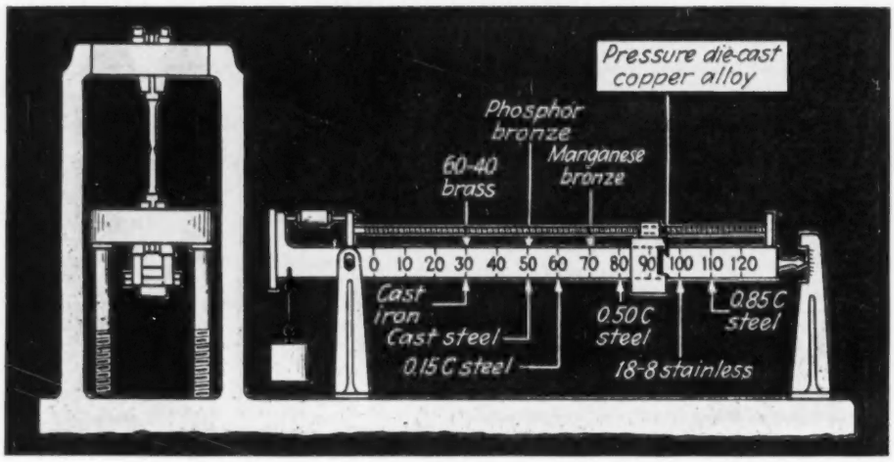
Common Color Illusions

ACCORDING to an article in the Du Pont *Automobile Color Index,* wide strips of contrasting colors adjacent to one another are disagreeable-looking. The usual procedure for promoting harmony is to place a bit of one color into the other, and vice versa. This tends to effect an improvement but at the expense of brilliance. Brilliance may be maintained by the simple expedient of alternating fine lines of the contrasting accent colors. If it is not practical to alternate the lines that go to comprise the stripe, then a well-defined outline color serving to separate the discordant colors will help to alter the effect.

When we look at a strong chroma color for a time, there results a partial exhaustion of the visual process with the result that an after-image is seen. The after-image appears of a color complementary to the color of the object. When the fatigue is caused by red, the after image on a white surface is blue-green. Since the components of white light are red, green and blue, when the eye can no longer, through fatigue, respond to red, the after image is blue-green.

A spot of weak color surrounded by black or white makes it possible to intensify its importance. Leaded windows in cathedrals bear mute testimony to the potentiality of the effectiveness of outlining small patches of color with black. A jewel-like quality of color brilliance obtainable in no other manner at so little cost, is the result.

Research develops commercial brass die-castings with a strength of 90,000 lb. per sq.in. and all the desirable properties of an 81 per cent copper alloy



Metallurgy Perfects Strong-As-Steel Die-Castings

BECAUSE of the high melting point and the tendency when molten to erode steel dies, high-strength copper alloys have been difficult to die-cast. Only forgings and sand castings have been commercially available when the strength, toughness and corrosion resistance of copper alloys were desired. But recent metallurgical advances in high-strength copper alloys and steels for die-casting molds now give the designer the opportunity to use copper alloy parts having the strength of steel, the corrosion resistance of an 81 per cent copper alloy and with the economical cost, dimensional accuracy and smooth surfaces characteristic of die-castings.

This new development required the solution of several problems in die-casting. New methods of die-casting and new types of equipment were required to obtain the combination of high strength and good ductility. And the high contraction of the metal in cooling from a relatively high temperature made necessary a new technique in die design, particularly for intricate parts.

That these production problems have been solved is shown by the complicated parts illustrated here having varying wall thickness, cored holes, long extensions and thin sections, manufactured by the Doehler Die Casting Company from an alloy marketed under the trade name of Brastil.

As an example of the application of these die-castings, the part shown below at the left is a printing hammer used in the Chronolog. According to Theodore Eichhoff, chief engineer of the Chronolog Division of the National Acme Company, the constant hammer blows—as many as four or five per second—required an alloy having high strength and toughness. And as the part must operate practically without lubrication it was also necessary to use a metal having good

Typical high-strength copper alloy die-castings that are subjected to high stresses and impact. These die-castings are also corrosion resistant and have a smooth surface

bearing qualities. These requirements were met by the new die-casting alloy and by using a die-casting the design was simplified by combining a number of parts. Also, the die-casting method eliminated much machining, leaving only the shaft hole to be drilled.

High strength and toughness are also needed in automobile parts such as those illustrated here. In the tire support and seat bracket high strength is essential. At the same time the die-casting has an excellent surface for plating, so essential for such automobile parts. For the door striker, toughness is required, while the special shape needed can be obtained by die-casting with no machining cost.

High-strength brass die-castings should be designed as die-casting and not merely a duplicate of the steel part. With the lower elastic modulus, load deflections in copper alloy parts will be greater than for similar steel parts, making it necessary to design sections with a larger moment of inertia if the deflection is to be limited. Likewise, the design must take into consideration the higher coefficient of expansion, and the fact that the material cannot be hardened by heat-treatment. At the same time full advantage should be taken of all the possibilities inherent in die-cast design.

Where the hardness of this copper die-casting alloy is not sufficient, steel inserts can be incorporated in the design where needed. As shown in the group above, even complicated parts can be adapted readily to the use of inserts. And in such parts, the contraction of the copper alloy is a distinct asset because it tightly anchors the steel inserts.

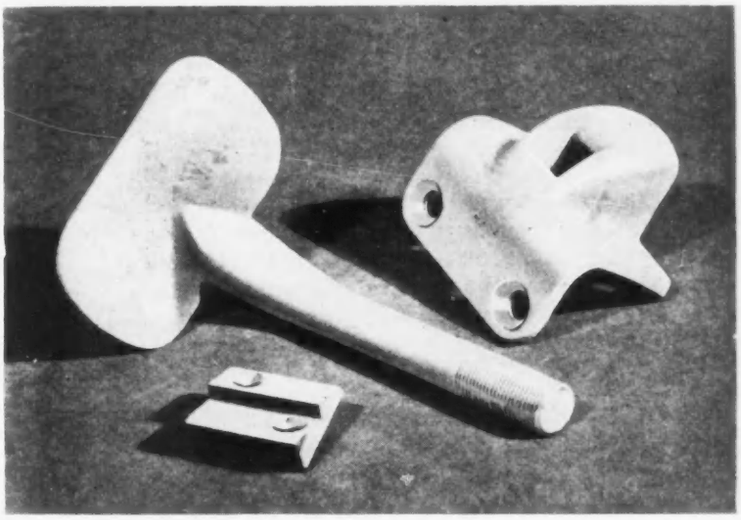
Included in these illustrations are only a few typical examples of copper-alloy die-castings that have given satisfactory service over a period of years. With the strength of steel, these die-castings combine the well-known advantages of the die-casting process with corrosion resistance, toughness, and good bearing qualities. They bring to the designer new opportunities for improving appearance, reducing the cost, and increasing the performance, serviceability and sales value of his design.

Physical Properties of 81 Per Cent Copper Die-Castings

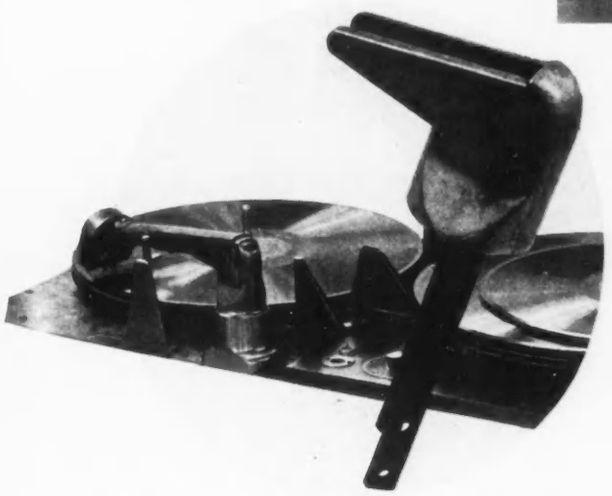
Courtesy Doehler Die Casting Company

Tensile Strength, lb. per sq.in.	85,000 to 90,000
Yield Point, lb. per sq.in.	60,000 to 70,000
Elongation, per cent in 2 in.	8 to 15
Brinell Hardness, 3,000 kg. load	160 to 180
Elastic Modulus	15,000,000
Impact, Charpy, more than	40 ft. lb.
Coefficient of Expansion in. per in. per deg. C.	0.0000175

Steel inserts can be put where needed to withstand severe wear



Die-cast automobile parts that must be tough and strong, tire support bracket, seat support, door striker



Steel inserts "stay put" in the pick-up arm support in the multi-record phonograph unit designed by Stromberg-Carlson

Sleeve-Type Bearings— Design and Protection

How to calculate the projected bearing area to assure stable full-film lubrication; minimum wall thickness for bearing shells; bearing protection and some common errors in the design of bearings are explained

C. H. LEIS
Chief Engineer, Johnson Bronze Company

AS WAS explained in the preceding article of this series "Fundamental Requirements for Bearing Lubrication" *(Aug. P. E., p. 303-305)* bearings require complete film lubrication, otherwise they will overheat and probably seize. From this it follows that the initial step in the design of any bearing is to determine the dimensions that will insure complete film lubrication and also a minimum coefficient of friction.

Two different formulas are in use for determining the size of the bearing. One specifies a certain maximum value for the product of unit pressure on the projected area times the surface velocity of the journal. The maximum value of this product is different for different types of bearing service, the factors having been established by tests and observations. The viscosity of the oil does not enter into the calculations when using this empirical PV formula, which has resulted in unsatisfactory results in some instances.

A more comprehensive formula which was developed more recently and has proven highly satisfactory is the relationship:

$$ZN/P = C$$

As shown by Fig. 1, wherein this equation is plotted as a curve, for minimum friction the value of C should be as small as possible and yet assure complete film lubrication. That is, the minimum value of C should be slightly to the right of the transition range T indicated on the chart.

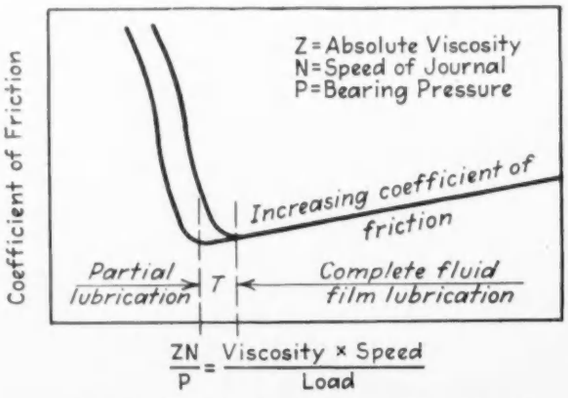


Fig. 1—In designing bearings, the value of P relative to Z and N must give a value of C to the right of the transition range T

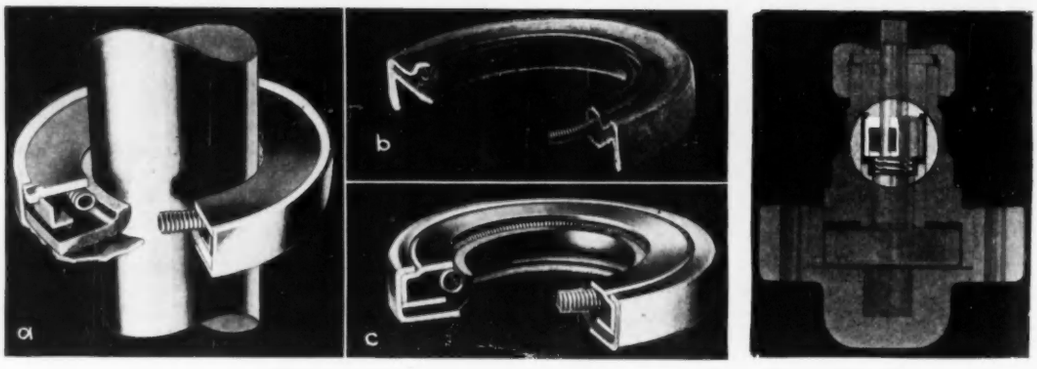


Fig. 2—Typical bearing seals: (a) "Perfect Oil Retainer," Chicago Rawhide Mfg. Co. (b) "Type J Single Seal," Michigan Leather Packing Co. (c) Newest type of National Motor Bearing Co. seal. At the extreme right, sealing unit made by Rotary Seal Co. as applied to an oil burner

The minimum safe value of C will be affected by the material of the bearing, the condition of the journal surface, the ratio of length to diameter of the bearing and the ratio of clearance to diameter. A small ratio of length to diameter, such as less than 0.75, will cause an increase in friction because end-leakage of the lubricant will decrease the effective bearing area by a large percentage. An excessively large ratio of length to diameter is liable to cause excessive friction on account of the difficulty of securing and maintaining perfect alignment between the shaft journal and its bearing.

Bearing clearance ratio will be determined by the accuracy with which the bearing elements can be fitted and the type of bearing material used. With plastic bearing material accurately fitted, the clearance may be as low as 0.001 in. per in. of journal diameter. For bronze bearing metal with lead up to 12 per cent, the clearance should not be less than 0.0015 in. per in. of journal diameter.

If the bearing is designed with a value of ZN/P calculated to give minimum friction under normal running conditions, there will be no margin of safety. Momentary overloads, a drop in speed or a lowering of the viscosity of the lubricant caused by unexpected higher operating temperature, will decrease the value of C. The bearing will then operate in the region T, Fig. 1, where the oil film is unstable, or perhaps may operate even in the region of partial lubrication. This is the most frequent cause of bearing failure. With the journal running in partial contact with the bearing, wear will be rapid and the bearing will soon fail. In other words, the selected value of C should be sufficiently above the ideal minimum to make sure that the bearing will always operate in the region of complete film lubrication.

To make certain that the bearing will always operate in the region of complete film lubrication, the theoretically minimum allowable value of C is multiplied by a safety factor. For applications where it is expected that the bearing will be given careful attention, a factor of 5 is ample. Where relatively little attention will be given the bearings, a factor as high as 15 might be used.

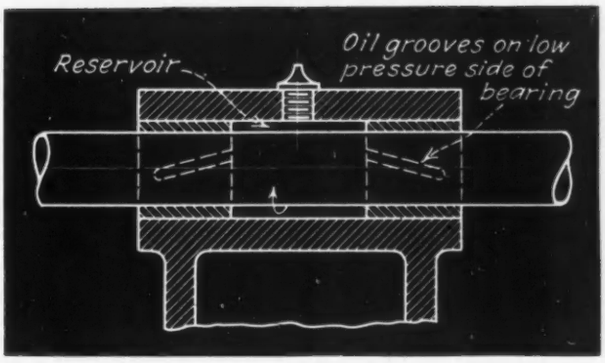


Fig. 3—Two short bearings in place of one long one, will permit better alignment and provide a reservoir for lubricant

Table II—Relation Between Absolute and Saybolt Viscosities

Saybolt Universal Seconds	Absolute Viscosity in Centipoises	
	Specific Gravity	
	0.80	0.90
32	0.9	1.0
40	3.3	3.8
50	5.9	6.7
100	16.5	19.5
150	21.3	23.8
200	34.9	39.3
250	43.8	49.2
300	52.6	59.2
400	70.4	79.2
500	88.0	99.0
600	105.5	118.7

Table I—Value of C for Various Types of Shafts and Bearing Materials

Bronze with 12 per cent lead or more is considered plastic when the tin content is 7 per cent or less.

Shaft	Type of Bearing	Value of C
Hardened and ground	Babbitt	20
Machined soft	Babbitt	25
Hardened and ground	Plastic Bronze	30
Machined soft	Plastic Bronze	35
Hardened and ground	Rigid Bronze	40
Machined soft	Rigid Bronze	50

Incorporating this safety factor F in the fundamental equation, we have:

$$ZN/P = CF \qquad (1)$$

or,

$$Z = CFP/N \qquad (2)$$

Since the unit bearing pressure P on the projected area is the load L divided by the projected area A, or L/A, we can substitute for P its value L/A. Thus:

$$ZNA/L = CF \quad \text{or} \quad A = CFL/ZN \qquad (3)$$

In applying the above equations it is necessary to select the value of C. The values of C for various types of shafts and bearing materials are given in the accompanying Table I. The factor F should range from 5 to 15, as explained above. The viscosity Z of the lubricant is the absolute viscosity expressed in centipoises. From the known Saybolt viscosity of the lubricant to be used, the absolute viscosity in centipoise can be gotten from Table II for 0.80 or 0.90 specific gravity oil.

To illustrate the application of the above equations, assume that a babbitt bearing for a hardened and ground journal is to be calculated for a bearing load $L = 400$ lb., a speed $N = 1{,}500$ r.p.m., and to be lubricated with an oil having a Saybolt viscosity of 100S and a specific gravity of 0.80. Assume good bearing protection and attention, hence a value of $F = 5$ will be taken.

From Table I, C for a hardened and ground shaft running in a babbitt bearing is 20. From Table II, the absolute viscosity corresponding to 100S Saybolt and

0.80 specific gravity, is 16.5. Substituting the known figures in Equation (3):

$$A = CFL/ZN$$

$$A = \frac{20 \times 5 \times 400}{16.5 \times 1500} = 1.6 \text{ sq. in.}$$

For a shaft diameter of 1.25 in., the length of the bearing would be 1.6/1.25 = 1.28, wnich gives a fair ratio of length to diameter.

Sometimes it may be required to find the viscosity of a lubricant in order to assure complete film lubrication in a given bearing. As an example, assume:

Operating temperature normal
Safety factor $F = 15$
Speed of shaft, $N = 900$ r.p.m.
Length of bearing = 3 in.
Diameter of journal = 4 in
Load $L = 240$ lb.

Using these data:

Bearing area $A = 3 \times 4 = 12$ sq. in.
Unit bearing pressure $P = 240/12 = 20$ lb. per sq. in.
From Equation (2):

$$Z = CFP/N$$

$$= \frac{50 \times 15 \times 20}{900} = 16.6 \text{ centipoises}$$

From Table II, a lubricant with an absolute viscosity of 16.5 centipoises and a specific gravity of 0.80 has a Saybolt viscosity of 100 sec.

Wall Thickness

The minimum thickness of a sleeve type bearing is primarily governed by the type of bearing material, the construction of the housing and the manner in which the sleeve bearing is assembled in the housing. In some types of bearings the wall thickness will be governed by the manufacturing methods to be employed in the assembling of the bearing. However, the following figures will give the wall thickness usually used for the various types of bearings.

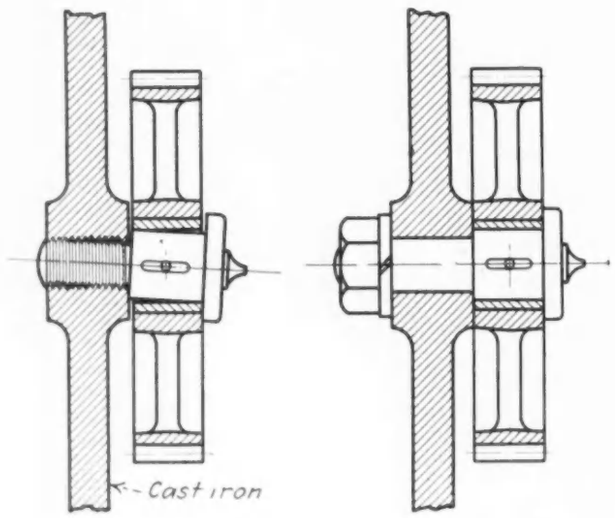


Fig. 4—The design to the left is unsatisfactory; the one to the right is more rigid and the load distribution is uniform

Cast Type—Cast bronze bearings usually have a wall thickness of $\frac{1}{32}$ in. to $\frac{1}{8}$ in. per in. of journal diameter. For economic reasons, the low ratio is desirable.

Sheet Bronze Type—For sheet bronze bushings, a maximum wall thickness of 0.065 in. is recommended. This thickness facilitates economical manufacturing and also will give best results in seating the bushing in the housing by burnishing in the assembly.

Laminated Bearings of Strip Steel—The thickness of the steel in formed laminated bearings should not exceed 0.065 in. The standard thickness used in the automotive industry is 0.050 in. steel thickness and 0.020 babbitt. The steel thickness may be varied provided the quantity of bearings required warrants the expense of the equipment changes.

Bearing Protection

Protecting devices or seals, if applied to sleeve type bronze bearings will return their cost many times in savings of both bearing and journal. Costly breakdowns involving both lost time for the machine and the expense of repairs, may thus be prevented. Dust, grit, and other foreign matter play havoc with bearing performance and injure the surfaces. Under certain operating conditions it is almost imperative that the bearings be protected. Even though some bearing materials offer resistance to withstand abrasion, their life can be increased materially if foreign matter is excluded.

There are a number of recognized bearing seals obtainable. Such seals are designed not only to prevent foreign matter from entering the bearing, but also to prevent the escape of lubricants. The particular type of bearing seal selected should be designed to meet operating and mechanical conditions. Fig. 2 shows several types of effective seals.

High-speed bearings are best protected by seals of a type that permits no friction.

If the same care and attention with reference to protection is given to sleeve-type bearings as is applied to ball or roller type bearings, there can be no question of increased life and performance, even under the most adverse conditions. Uncontaminated lubricant and an abundance of it makes for bearing insurance. The economic feature of the bronze sleeve-type bearing permits the additional further investment in effective bearing seals.

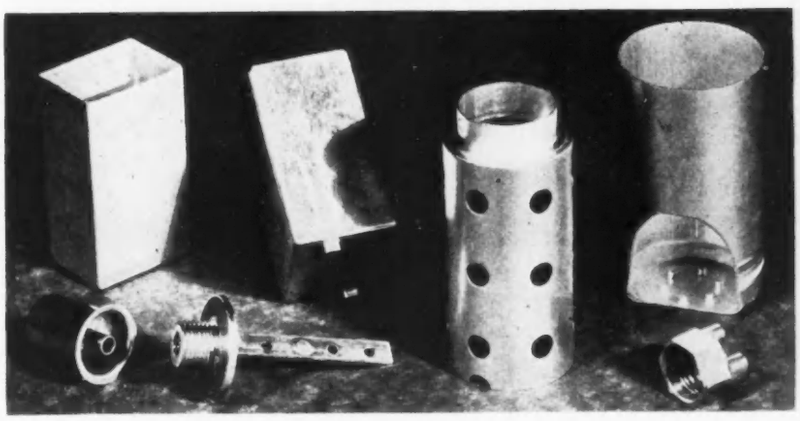
In many applications, where long bearings are required, it is more economical to use two short bushings as shown in Fig. 3. This has further advantages in that it will conform itself more readily for alignment and provides a reservoir for the lubricant. Long bearings are difficult to produce to the accuracy required and in many cases alignment cannot be maintained in the assembly due to the temperature changes of the bearing. A bearing will perform more efficiently when the ratio of bore to length is not less than one and not greater than in the ratio of one to two.

In machine design it is often required to mount moving parts on single bearing studs. If the bearing support is of the nature as shown to the left in Figure 4, bearing performance will not be satisfactory. On the right of Fig. 4 is shown an improved design which will assure rigidity of the stud and the proper distribution of the load on the bearing.

Designs That Can Be Made By Impact Extrusion

Can-shaped parts made by impact extrusion may have thin walls and thick bottoms, while bosses, lugs, rivets, stems or necks can be made integral with the closed end

HERBERT H. HALL
Aluminum Company of America



RELATIVELY shallow shells or cans of uniform metal thickness throughout can usually be made most economically by pressing or drawing. But when the depth-diameter ratio exceeds about 1½, the number of operations required to draw the part to the desired depth, greatly increases the cost. Another problem arises when it is necessary to have bosses, lugs, rivets, stems or necks on the closed end of the shell. Or it may be required to have a bottom considerably thicker than the walls, with perhaps embossing on the inside or outside of the bottom. Such designs would in most instances be impossible to make as a one-piece stamping. Designed as separate parts put together by riveting, welding or screw joints, the complete assembly may be cumbersome and unsightly, with the possibility of the assembled parts getting loose. Designing the parts to be made by die-casting or by impact extrusion may solve the problem.

Restrictions imposed upon the engineer and the design possibilities in the use of die-cast constructions are quite well known. The design limitations imposed by the impact extrusion process and its field of application can be understood from a consideration of the method by which such parts are made.

In forming a can or shell by the impact extrusion process, a relatively thick round disk or slug is placed in a shallow cup-shaped die in a power press. The punch, the diameter of which is smaller than that of the die, then strikes the slug. This forces the ductile metal of the slug to flow through the annular clearance between the punch and die and flow upward around the punch. Thereby is formed a can or shell, the bottom of which is the slug of metal remaining in the bottom of the die and the wall of which is the metal that has been extruded out of the die and around the punch.

Impact extrusion is virtually a squirting operation, and because the metal extruded must be extremely ductile, relatively few metals are suitable for this process. Even then it requires extra heavy machinery of special design and tools of the strongest steels to withstand the tremendous pressures that must be applied to make the metal flow.

Among the metals that have sufficient ductility for

the impact extrusion process are tin, lead and aluminum. Neither tin nor lead have the physical properties usually required for mechanical parts and their use is confined primarily to the manufacture of impact extruded collapsible tubes such as used for packaging tooth-paste and similar commodities. On the other hand, pure aluminum not only has a relatively high strength, but it also has other properties that make it particularly suitable for impact extrusion. In the annealed condition, the aluminum is soft, ductile and malleable, making it easy to extrude. But the cold working that it receives during the extrusion operation adds both strength and stiffness to the finished parts. If stiffness is not desired, the extruded parts can be annealed at a temperature of about 800 deg. F., for about 20 min., which makes the metal soft and pliable, as required for collapsible tubes.

Factors Affecting the Design

In addition to pure aluminum, some of the alloys of this material can also be used for mechanical parts extruded by impact. These alloys contain only a small percentage of alloying elements and the type of alloy used depends greatly upon the details of the design of the parts to be made. A simple heat-treatment of the extruded part greatly increases its strength above that of pure aluminum. However, for most applications pure aluminum is used, and the work hardening it receives in the extrusion operation usually results in a mechanical part that has the desired strength and stiffness.

A study of the diagram showing the impact extrusion operation, reveals the following factors and requirements:

1. The extrusion pressure must be sufficient to compel the metal to flow upward around the punch.

2. To keep the extrusion pressure within reasonable bounds, the punch and die should be shaped so that the flow of metal will be facilitated. The flow of metal will be facilitated by a conical die bottom, as illustrated. This shape of die bottom also helps materially to keep the punch central.

3. The side walls of the can or shell must be straight.

4. The maximum length of tubes or shells that can be impact extruded is limited by the length of the punch or the die space available in the press, the volume of metal that must be extruded and the extrusion pressure required. As an approximate figure, 10 in. is about the maximum length for extruded and trimmed tubes or shells.

5. In the design of parts to be made by impact extrusion, the wall thickness of the shell or can must be symmetrical in order that the punch will be balanced with reference to lateral pressures. If the pressure is unbalanced, the punch will be crowded over and possibly bent.

Perhaps the biggest single factor that establishes the extrusion pressure required is the strain hardening of the metal. As the punch continues down into the die, the remaining metal in the blank becomes strain-hardened and becomes more difficult to extrude. That is, the extrusion pressure increases as the punch reaches the end of its stroke, thereby limiting the amount of metal that it is possible to extrude.

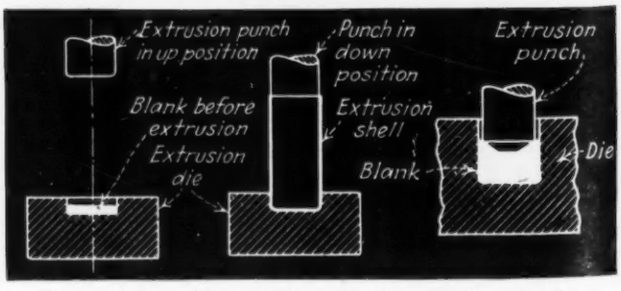
The minimum wall thickness that can be obtained with the impact extrusion process with a conical closed end is approximately 0.003 in. This minimum wall thickness will vary with the diameter of the tube or shell. For flat-bottomed cans $\frac{1}{2}$ in. in diameter, the minimum practical wall thickness will be 0.010 in., for $1\frac{1}{2}$ in. diameter, the minimum will be 0.015 in. For shells 4 in. in diameter, the minimum wall thickness will range from 0.032 to 0.045 in. The larger the diameter, the heavier must be the wall.

Variety of Shapes Obtainable

Tolerances in the wall thickness as affected by eccentricity will vary with the wall thickness. The heavier the wall, the greater must be the tolerance. However, another factor here is the shape of the bottom. If the bottom of the shell is flat there is liable to be greater eccentricity between the inside and outside surfaces than would be if there were a conical bottom. Also, as a generality, the eccentricity will range all the way from less than plus or minus 0.001 in., to plus or minus 0.005 in., depending upon the details of the design and the size. The walls must be straight, but the outer or inner surface may be fluted or ribbed.

Because of the nature of the impact extrusion operation, bosses or projections of any kind can be put on either the inside or outside of the bottom of the shell. By careful design, it is possible to combine rivets, bosses, screws and similar elements as an integral part

Stems or nozzles can be impact extruded without difficulty and finished by spinning, knurling, threading or punch-press operations



The metal squirts out through the annular opening between the punch and die. A conical bottom as shown to the right permits metal to flow more readily

of the design. Numerous examples of this are shown in the accompanying illustration.

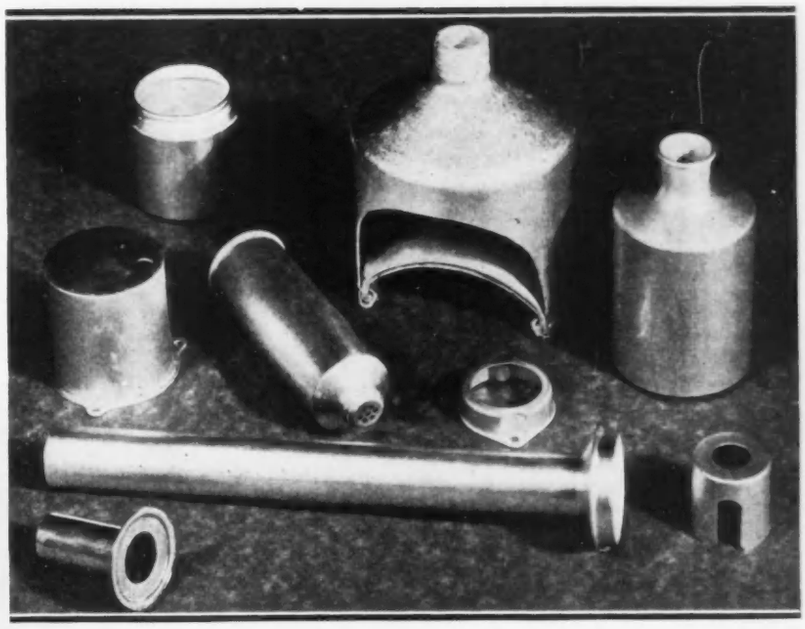
It must not be assumed that impact extruded parts are confined to shells or tubes of circular form. Oval or rectangular shape can be made with equal facility. Special shapes such as shown in the accompanying illustrations can also be made. However, because the periphery per unit of area of a square can is greater, such a design is slightly harder to extrude than a round one, there being a greater amount of friction involved. As a general statement, the extrusion pressure increases rapidly as the area of the blank increases and as the frictional resistance of the side walls sliding up the punch increases. And, of course, the strain-hardening of the metal remaining in the die is also a governing factor.

There are only a few refinements with reference to the design of the bottom of the can or shell. Thus, the corner radius in the inside of the bottom should be not less than $\frac{1}{32}$ in. Also, the bottom of an extruded can is slightly thicker than the side walls. A fillet on the inside corner is desirable to facilitate the flow of metal around the end of the punch, which also helps to reinforce the shell at this point. And this combination of heavy bottom reinforced by a fillet, with perhaps the addition of ribbed walls, and the metal hardened by the cold working, results in a product that is particularly suited for service where severe usage is expected.

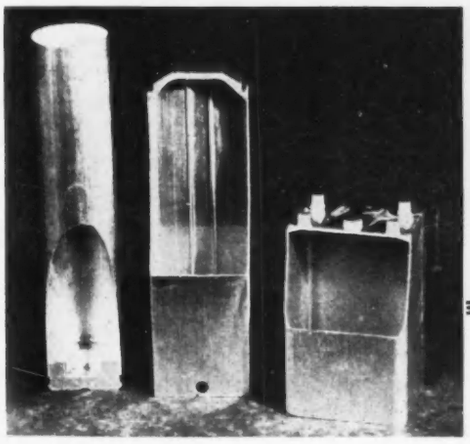
Seamless shells made by impact extrusion also have a great advantage where attractive finishes are required. Such shells can be enameled or lithographed or the alumilite process can be used to obtain beautiful color effects of great durability. The plain alumilite finish is effective where a hard and corrosion-resistant coating is required. For certain purposes the natural finish of the aluminum may be desired, in which case the aluminum may be highly polished, dipped or satin finished. If desired, the extruded part can be electroplated.

Regardless of the length of the shell, impact extrusion involves only one operation whereas several might be required in drawing the part. Also, with only one set of tools it is possible to impact extrude a shell of almost any length or wall gage proportions merely by varying the volume of the blank. Thus the tool expense for extruded parts is considerably less than that for drawn parts, especially where the latter require several operations and several sets of tools.

Impact extruded parts can be modified in any manner desired by subsequent operations, and can be assembled with stampings, as illustrated by the parts shown here



Rectangular shapes can be impact extruded with equal facility. Bottoms can be made virtually any shape or thickness and walls can be ribbed



In addition to the shapes that can be obtainable directly by the impact extrusion process, the extruded part can be further developed by forming, stamping or spinning operations. Thus, flanges can be stamped or spun on the shell, or the shapes can be modified in any manner desired. Machining operations can also be applied to the heavy bottom or projecting stems, such as threading, knurling or any cutting operations.

A complete list of aluminum parts that can be made by impact extrusion would be virtually endless. In addition to the numerous designs shown in the accompanying illustration, tube coil and transformer shields for radios, electrolytic condenser, tubular anodes and cathode cans and containers, foil condenser cans and casings, collapsible tubes, grease guns, filter cases, door checks and pump cylinders; ignition coil cans; electric heater shells; rubber dipping forms; flashlight and cartridge cases; textile bobbins and sleeves; fire extinguisher tanks; refrigerator drain pipes and innumerable other parts can be made.

Learning Rule and Rote Does NOT *Make A Designer*

G. F. NORDENHOLT
Managing Editor

If mechanical engineering graduates are to be better prepared to enter into the work of product designing, college courses must more truly reflect design procedure as conducted in industry

LAST June at the meeting of the Machine Design Division of the Society for the Promotion of Engineering Education, at Cornell, more than half a hundred machine design teachers from all over the country discussed the problem of improving their courses. Papers, discussions and informal comments left the impression that here was the beginning of a movement, the effects of which will be felt in every engineering department in industry.

It is evident that the basis upon which to improve college courses relating to product design is a study of the work and methods of an engineering department. This establishes the specifications that the graduate engineer must meet when he starts on his career as a designing engineer. It also indicates the foundation he must have in order to profit from his experiences and develop into a man with professional standing. Admitting this contention, then, the question is what is the procedure in the development of a new product?

Design procedure as conducted in industry is not a succession of calculations with a random selection of materials. Before any machine design calculations are made, existing designs are studied in conjunction with market requirements. Possible improvements in the present product are analyzed and a tentative balance between costs and market values is established. Definite lines of attack are prescribed and a number of preliminary designs are drawn and analyzed. The design selected is then developed, each element and unit being made the subject of careful study. Several different materials may be considered for a given part. The problem is to select that one which will give the best balance of requirements versus properties and cost.

What are the fundamentals in design procedure that might be taught successfully in college? I have never seen them tabulated or even mentioned in any machine design text book. But here are a few of them: (1) In any assembly of associated parts, the machine should be studied for the purpose of eliminating unnecessary connecting members; (2) every machine should be studied as to the possibility of making one element serve a multiplicity of purposes; (3) the product should be analyzed with reference to unit or subassemblies in order to simplify the manufacture, maintenance and replacement of parts and improve the appearance as well; (4) in selecting the materials, it should be considered that the most economical material to use is not necessarily that one which costs least per pound, as demonstrated by die castings, steel stampings and molded plastics; (5) it should be remembered that the material used will often dictate the manufacturing methods to be employed, which will in turn determine the character of the design. Thus, die castings, stampings, molded plastics and drawn sections usually permit combining several parts into one piece.

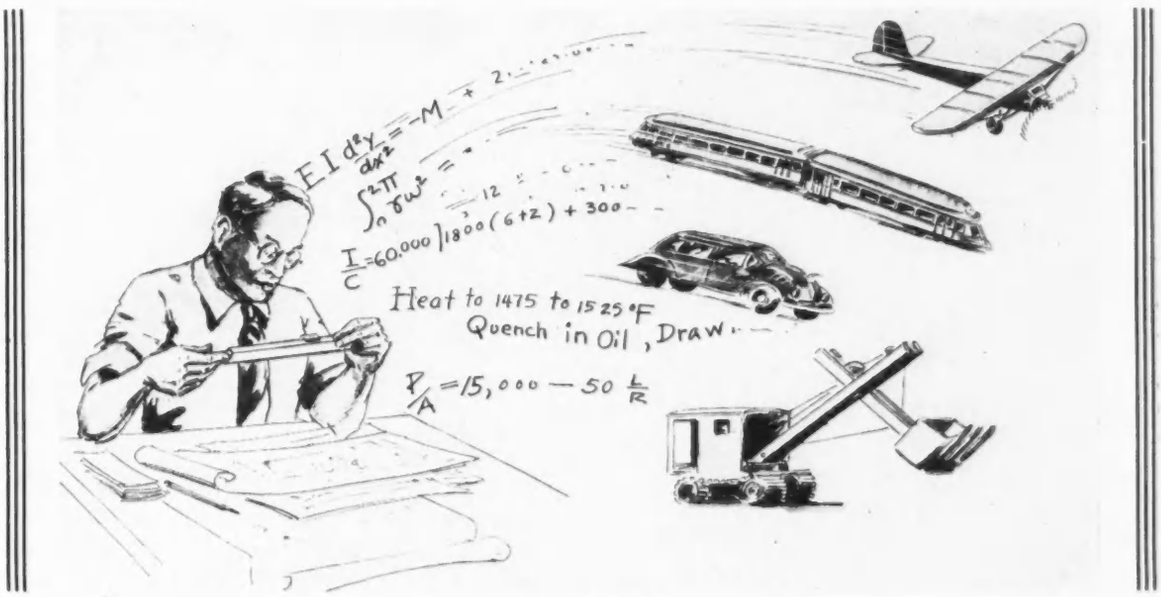
Numerous other fundamental considerations in design procedure could be mentioned, enough for a course in "design procedure and considerations." Taught in the abstract they would be dull, uninteresting and probably would not leave a lasting impression. But presented as the applications of fundamentals by which certain designs, taken for purposes of illustration, were developed, they would stir the imagination and capture the interest of any student actually interested in mechanical design. "Successful Products and How They Were Developed" could well be the title of a "machine design" text book, to be used for teaching the philosophy of designing products and machinery.

But before a student could profitably study the philosophy of product engineering he must have learned mechanics, mechanisms and materials. They are the basic fundamentals, and it is significant that the costly failures in engineering design are more often the result of ignorance of or the improper application of engineering fundamentals. To mention only a few, a recent failure of locomotive axles was found to be the result of the combined stresses of the shrink-fit of the wheel and the bending moment on the axle. The repeated failure of a "solid end" connecting rod was found to be caused by the stress concentration around the hole for the crank pin, which stresses were further concentrated

by an oil hole drilled at right angles to the rod and in line with the crankpin center. The originally manufactured heads of chrome steel rivets that had been driven in a tank snapped off during the riveting of the tank because the driven rivets were brittle and were made with a sharp corner under the head; low-carbon steel rivets snapped off in a similar manner in service because they had been driven into oversize holes, thus forming a crease under the original head. A shaft designed hollow, to give maximum strength with minimum material, snapped because it was too stiff to absorb the impact loads to which it was subjected; flat, ribbon-type springs broke because they had been anchored by spot welding. A sheet-catcher was to operate 60 per cent faster, for which reason the size of motor was doubled, but the motor burned out because the power to overcome inertia is proportional to the square of the maximum speed. The crankshafts of the Graf Zeppelin snapped because lighter clutch springs had been substituted for the original ones. This

students behind the scenes and into the conference rooms of the engineering departments would make contributions of tremendous value. Thus could be portrayed the tension and excitement when a new design is being developed to match or beat the competitor's product. Thus could be demonstrated how the drab dead formulas of physics, mechanics and metallurgy spring to life in the engineering departments and resolve themselves into automobiles that can do 100 mi. per hr., power shovels that can lift a house, radios that can be carried in the pocket, airplanes that carry 50 passengers and cruise 3,000 mi., railroad trains that glide noiselessly at 117 mi. per hr. and mechanical equipment for the home that does the labor of 100 hands.

Time is short and the art is long. Improvement in courses can be brought about only by discarding "worn-out" subjects. I dare say that almost every professor of machine design will find in his course assignments of sentimental rather than intrinsic value. Old age throws



Drab dead formulas spring to life and resolve into 50-passenger airplanes that can cruise 3,000 miles, trains that glide noiselessly at 117 miles per hour, automobiles that do more than 100 miles per hour, and power shovels that can lift a house

changed the inertia of crankshaft assembly and allowed torsional vibration with resulting fatigue failure. Numerous similar instances of engineering design failure could be cited, and many more have never come to light.

How would it be possible to stimulate the students so that they will visualize the glamour, as well as the drudgery, in the work of a product engineer? The personality of the professor is a large factor and his ability to dramatize outstanding engineering achievements would be more fruitful than any textbooks or prescriptions of courses. Perhaps the second greatest influence would be lectures by engineering executives who are active in product engineering work. A careful selection of good speakers who in themselves will serve as an inspiration, who can talk interestingly about the philosophy of engineering design and who can take the

a halo of dignity around even the useless. A number of such assignments that belong to antiquity come to mind. One is: select from a specified catalog the size of roller bearing for a given journal diameter, load and speed. Quote the Underwriters Specifications on fire pumps, or design a punch press, triplex pump or crane, are in the same category. More could be cited.

But regardless of opinions concerning details of procedure, textbooks and teaching methods, let the professors of machine design and mechanical engineering call upon industry to help. And such assistance should include not only advice on the content of courses but also material help in the form of lectures, laboratory equipment and demonstrating models. Industry profits from the product of the colleges—let industry contribute to the improvement of that product.

QUESTION AND COMMENT

High-Speed Friction Drive

G. N. KROUSE
New Kensington, Pa.

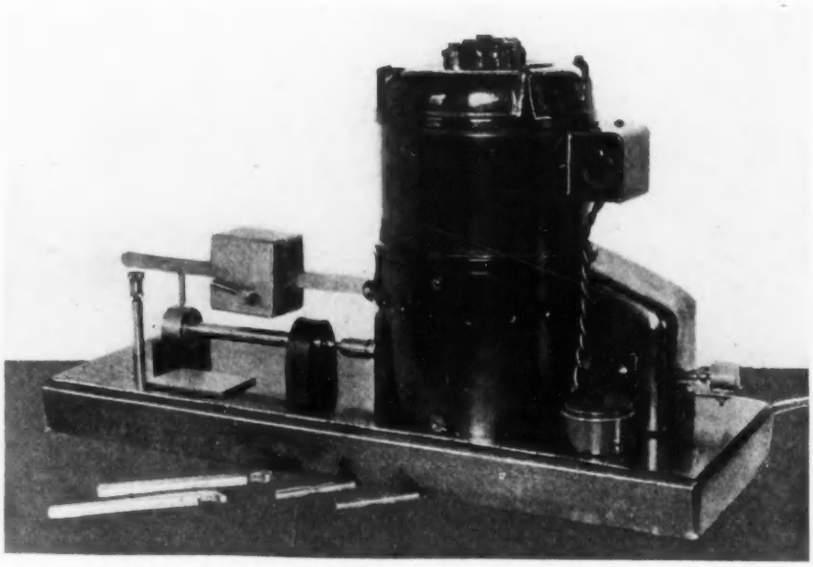


Fig. 1—Endurance limit data are obtained quickly at low cost in this portable machine by rotating a small specimen at 13,500 r.p.m.

● Disadvantages in making routine endurance or fatigue tests on the usual types of equipment are the length of time required, the cost of the machine and the cost of preparing specimens. To obtain data for a complete curve on one material requires four to ten specimens subjected to a total of 25,000,000 or more reversals of load. Thus, for a single machine operating at 1,500 reversals per minute, more than a week would be required to complete the test. But with the compact machine shown in Fig. 1, recently developed by the author at the University of Illinois, the test is completed within 24 hours, the machine being designed to give 13,500 reversals per minute.

By designing the machine to test a small specimen the cost of machining the specimen was reduced, as well as making possible a small, portable machine requiring but little power. A standard horizontal $\frac{1}{6}$ hp. 3,500 r.p.m. motor mounted with the armature shaft vertical rotates the specimen through a step-up friction drive. The weight of the armature and shaft exerts the required pressure between the faces of the friction wheels.

The large cone attached to the motor shaft extension as shown in Fig. 2, is of mild steel, driving against a small, hardened steel cone pressed on the high speed shaft. Contact pressure between the cones is low so that there is no measurable wear and no surface cracks are liable to develop from repeated stresses. At the same time the slippage under full load is less than 1 per cent. Thus vibration, noise and wear are a minimum.

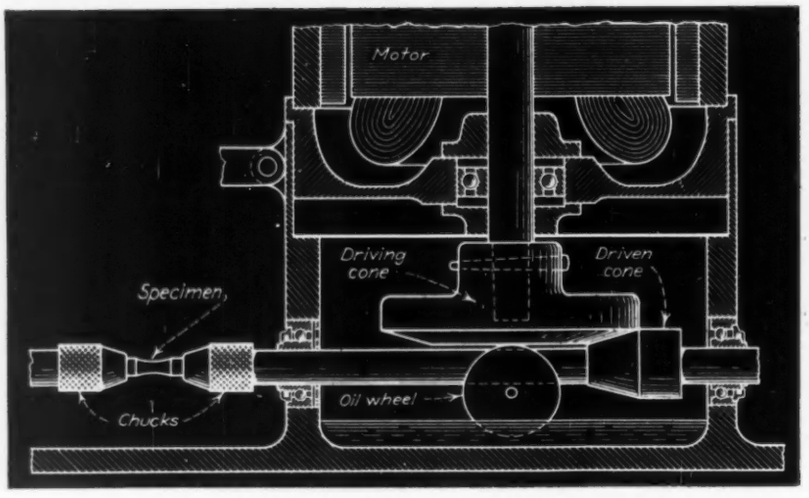


Fig. 2—Friction cone-drive and spindle bearings are effectively lubricated by an oil wheel driven by contact with the cone

Satisfactory lubrication for the friction drive and the two bearings on the high-speed shaft is supplied by a small wheel held in light rolling contact with the large driving cone. The lower portion of this wheel, as shown in the diagram, picks up oil from the sump in the base of the machine, transferring part of this oil to the driving cone. Centrifugal force throws the oil off the cone and into the ball bearings that are mounted in the housing. These bearings are sealed on the outside. The single sealed ball bearing shown to the left in Fig. 1 applies a bending load to the cantilever specimen and being loaded only lightly can be kept lubricated satisfactorily by adding a few drops of light oil once a month.

In any endurance testing machine, natural frequency vibrations tend to increase the dynamic load on the specimen. The speed of 13,500 r.p.m. in this machine is far above the 1,000 cycle frequency of the loading system, while the

use of a stiff spindle and short spacing between the spindle bearings raises the natural frequency of the shaft considerably above the operating speed. The use of a friction drive likewise reduces torsional vibrations that otherwise might be transmitted to the specimen.

Stresses in Connecting Rods

To the Editor:

● With reference to the problem submitted by Henry Bohn in the April number of *Product Engineering*, page 149, and partially answereed by A. G. Solakian on page 308 in the August number, it appears that the most important factor concerning the design of connecting rod ends has been totally ignored.

Ordinary methods of calculating the stresses in connecting rod pins assume that the end section is subjected to stresses similar to those found in a fixed-end beam. This, however, is far from true, as has been demonstrated by numerous connecting rod failures. In the first place, the rod end does not simulate either a fixed-end beam or a simple beam. The hole for the crankpin bearing in the rod causes a stress concentration which entirely upsets any beam calculation.

Furthermore, if an oil hole is drilled through the rod end in the usual manner, there will be a compounded stress concentration at the point where the oil hole breaks through the wall of the eye. Such a combination of stress concentration will develop stresses several times as great as the normal stresses calculated.

In addition to the stress concentration, it must be considered that these stresses are not steady, but repeated. Therefore, failure will take place as the result of fatigue stresses and not as the result of straight tensile or compressive stresses. With the endurance limit roughly one-half of the yield point of the material, it can readily be seen why rods carefully calculated on the basis of static stresses will fail in actual service.

—R. J. PALMER
New York, N. Y.

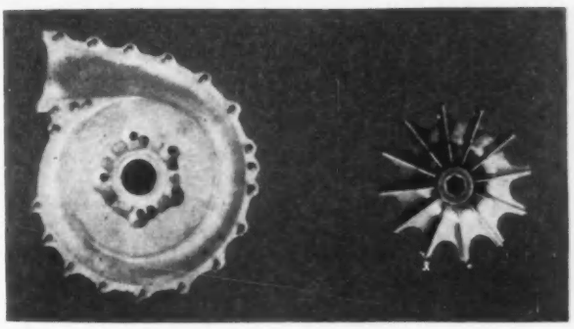
Magnesium Alloy Superchargers

To the Editor:

● In the article "Magnesium Alloy Parts" in the August number, the use of light-weight parts is said to reduce power requirements. In our experience, the greatest improvement resulting from the use of magnesium alloy for supercharger impellers has been the possibility of increasing the rotating speeds.

In the impeller, shown at the right in the accompanying illustration, the use of magnesium alloy makes it possible to run these blowers at 40,000 r.p.m., a higher speed than practicable with any other material. Also, the lower inertia greatly reduces the load on the gear drive, increasing the life of the gears.

Power required to accelerate the blower to its normal speed is one-third less with magnesium alloy than with aluminum alloy parts. This decrease in power required for the impeller appreciably increases the acceleration performance of the airplane engine. And, of course, the use of magnesium alloy for the supercharger case shown at the left, reduces dead weight without sacrificing strength or durability.



In Menasco airplane motors, the magnesium alloy impeller (right) takes less power from the propeller; the magnesium alloy case (left) leaves more weight for payload

H. G. TOWNSEND, Engineer
Menasco Manufacturing Company

Light Without Glare

E. L. ELLIOTT
Newmarket, N. H.

● Although illumination problems are usually of minor importance in mechanical design, problems of visual sensitivity, glare, eye strain and light intensities are factors that often must be considered. As mentioned in the article "Visual Properties of Sodium Light," on page 227 of the June number, new types of electronic light recently developed introduce visual effects not present under incandescent light.

The eye is subject to reflex stimulation varying with the wave length of the light, and since yellow light produces the greatest nerve stimulus, these rays have the highest exhausting effect. Like the fading of colors under sunlight, the exhaustion increases with the intensity of the light.

If the eye were not provided with a restoring means, it would soon become blind. The recuperative process present in the eye is greatly stimulated by light of short wave length—the blue and violet colors. In fact, visual sensitivity at low intensities can be increased by adding a small amount of blue light.

This recuperative power is not entirely dependent on reflex action for the eye will function indefinitely under light of any wave length at ordinary intensities. It is only when the retina is subjected to powerful radiant light that its operation is thrown out of balance.

High intensity is necessary to obtain high visual acuity. Under this condition, pure yellow light is glaring, while the addition of blue to the same light increases the restoring action of the eye, eliminating glare.

Where lower intensities of illumination are needed, pure yellow does not produce glare, and has the advantage of less absorption by floating particles in the air. This fact, in combination with the peak visual sensitivity in the yellow region, gives yellow light the highest penetrating power for a given intensity. Where air contains considerable dust or smoke, sodium light is not only the most penetrating color, but it has the lowest cost of production. Under higher intensities, however, high visual acuity without glare is a characteristic of mercury light, because of the presence of blue with its restoring power.

Why Avoid Large Wahl Factors?

To the Editor:

● In the July number of *Product Engineering*, page 280, C. P. Nachod presented a useful chart for the maximum load and deflection per coil in helical springs. The values in this chart are based upon D/d ratios embodying the Wahl factor, but it is stated that 8 is the best value for the ratio D/d, and that it should not be

less than 4 nor more than 10. The belief seems to be general that there is a best value for this ratio, fixed for all springs, this value generally being set around 8 to 10. All such dogmatic values for the optimum ratio of D/d should be challenged.

Apparently, the reason why small ratios are avoided is that the Wahl factor increases with smaller ratios. But this is merely a physical fact and does not make springs any less reliable or practical. It is a case of concentrated stress, and knowing the concentration factor, springs can be proportioned, as is done in other reliable structures having localized stresses. On the basis that the concentrated stress is to be avoided, the optimum value of the ratio is not 8, but infinity.

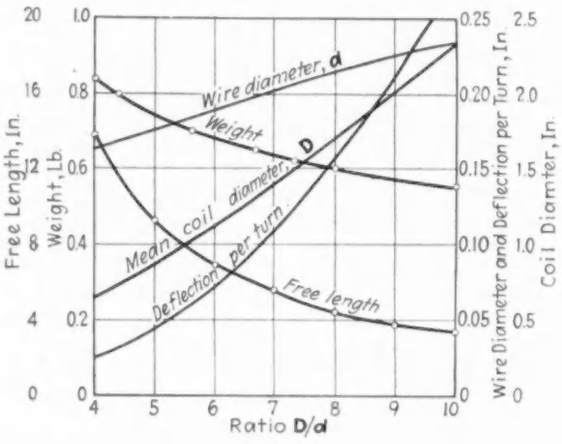
Only one possible value for the ratio of D/d exists when a spring problem is completely stated, that is, when the maximum and minimum load on the spring and its maximum and minimum lengths are given. This ratio may range from below 4 to above 20. Springs having a smaller ratio than the exact one will not fit into the length of space specified in the problem; springs having a larger ratio will have a larger coil diameter than is necessary.

—FREDERICK FRANZ
New Haven, Conn.

To the Editor:

● Helical springs designed by the charts prepared by Mr. Franz give but one outside diameter as a solution. When the design allows unrestricted length, but carries limitations on the spring diameter, a different procedure from that outlined by Mr. Franz is necessary.

With a specified working deflection at given maximum and minimum loads, various ratios of D/d enable choice of length with a spring diameter to best fit the particular design. Using the load requirements specified for the spring shown in the article by Mr. Franz in Fig. 6, page 217 of the June number, this spring has a deflection rate of 52.8 lb. per in. of compression. Dimensions of a series of springs having this deflection rate and the specified maximum load of 93 lb., for ratios of D/d from 4 to 10 are shown in the accompanying chart.



For the same deflection rate and maximum load, spring proportions vary with the ratio of D/d

A comparison of springs shown on this chart indicates how greatly a change in the ratio of D/d affects the proportions of the spring. For the spring having a ratio of 4, the compressed length is 12.3 in., and the mean spring diameter is 0.65 in. For a ratio of 8, these dimensions are 2.63 in. and 1.7 in., respectively. The weight is 0.83 lb. for a ratio of 4; with a ratio of 8 the weight is 0.605 lb.

From these curves it is apparent that the commonly accepted value of 8 for D/d gives a well-proportioned spring, having a free length of about two and one-half times the spring diameter. This, however, is the only reason for the use of a value of 8 for the spring index.

—CARL P. NACHOD.
Nachod and U. S. Signal Company, Inc.

Calf Paths

To the Editor:

● The following poem has been in my possession a number of years. The author is anonymous, but he must have known many engineers.

—L. R. RUSSELL,
Milwaukee, Wis.

THE PATH THE CALF MADE

One day through the primeval wood,
A calf walked home, as good calves should,
But made a trail all bent askew—
A crooked trail—as all calves do.

Since then two hundred years have fled,
And I surmise, the calf is dead;
But still he left behind his trail,
And thereby hangs my moral tale.

The trail was taken up next day,
By one lone dog that passed that way,
And then the wise bellwether sheep
Pursued the trail o'er vale and steep
And drew the flock behind him, too,
As good bellwethers always do.

And from that day o'er hill and glade
Through those old woods, a path was made;
And many men wound in and out,
And dodged and turned and bent about
And uttered words of righteous wrath
Because 'twas such a crooked path;
But still men followed—do not laugh—
The first migration of that calf.

This forest path became a lane,
That bent, and turned, and turned again;
This crooked lane became a road,
And many a horse with heavy load
Toiled on beneath the burning sun,
And traveled some three miles in one.
Thus for a century and a half
They trod in footsteps of the calf.

Then years passed on in swiftness fleet;
The road became a village street;
And this, before they were aware,
A city's crowded thoroughfare;
And soon the central street was this
Of a renowned metropolis
Where men two centuries and a half
Trod in the footsteps of that calf.

Each day a hundred thousand rout
Followed the zig-zag calf about;
And o'er this crooked journey went
The traffic of a continent.

A hundred thousand men were led
By a lone calf three centuries dead.
They followed still his crooked way
And lost one hundred years a day;
For reverence such as this is lent
To well established precedent.

A moral lesson this might teach,
Were I ordained and called to preach,
For men are prone to go it blind
Along the "calf paths" of the mind,
And work away from sun to sun
To do what other men have done.

They follow in the beaten track;
And in, and out, and forth, and back,
And still a devious course pursue,
To keep the path that others do.

The precept taught we all should heed.
For now it finds a crying need
Of application in the shop
And, not to let the lesson drop,
It does not with the workmen quit—
You engineers are hardest hit.

You plod and plod along the rut;
It wears so deep you can't see out.
Wake up, and climb to level ground
Where better paths lie all around;
Then choose with care the one you need
And hasten on with ten-fold speed.

Mechanical Springs of Stainless Steel

JOSEPH KAYE WOOD
Chief Engineer, General Spring Corporation

● Spring designers today need a non-corrosive material having the elasticity, strength and reasonable cost of our best spring steels. The reason for this becomes apparent when it is considered that the outermost or exposed fibers of a spring bar are stressed the most, and that the effect of corrosion becomes greater as the cross-sectional area of the material becomes smaller.

No material of a stainless character has yet been found that could be substituted for the best spring steel, either from the standpoint of high physical properties or cost. Only where resistance to corrosion is absolutely essential, have the so-called stainless steels been used in springs.

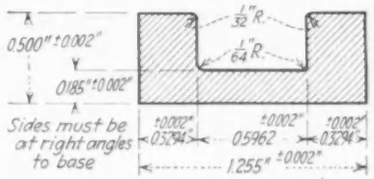
These steels may be classified under two general groups; the austenitic and non-austenitic steels. The austenitic steels are nearly always used in the manufacture of springs because the stainless properties are not dependent upon heat-treatment or polishing, and also because of the superior physical properties of these steels. To impart an austenitic structure to steel at ordinary temperatures requires a high content of both nickel and chromium, usually as high as 15 to 20 per cent nickel and 8 to 16 per cent chromium. The higher cost of these alloying elements prohibits the use of stainless steels in many applications where their physical properties are needed.

These steels are not only strong and tough, but also hold their strength well at elevated temperatures. This combination of resistance to heat and oxidation makes stainless steel springs well suited for service at higher temperatures than can be used for springs of ordinary steel. For this reason, an austenitic stainless steel spring has been used to maintain tension in the filament of high-power vacuum tubes.

Tolerances in Cold-Drawn Sections

To the Editor:

● In the article, "Cold-Drawn Steel for Special Sections" appearing in the July number, our hardness testing machine is shown in Fig. 1, mentioning the use of drawn steel for the pillars. Another drawn steel section, a channel shown in the accompanying diagram, is used as a guide in the head of the machine, making possible a



Fillets in internal corners reduce die wear

considerable saving in the cost of machining this part.

To obtain the desired tolerances using hot-rolled bar stock would require that the parts be machined all over. The cold-drawn section provides both dimensional and angle tolerances close enough so that much of this machining is unnecessary. Since sharp internal corners are not needed the use of the $\frac{1}{64}$ in. fillet in the internal corners is desirable in order to decrease wear in the drawing dies.

—C. H. WILSON
Wilson Mechanical Instrument Company

Charts for Barth Factors

To the Editor:

● On page 309 of the July issue of *Product Engineering*, A. C. Rasmussen criticises the chart for Barth gear factors reproduced on page 269 of the July number. In the reproduction of this curve only the main coordinate lines were shown. Had the subdivisions been shown the main chart and the insert would have been easily readable directly to the nearest five in the third significant figure. Also, it is easy to read to the nearest 0.0025 at any point on the chart by taking the midpoint between two lines, and more accurately on the enlarged insert for low velocities.

Several significant facts were not brought out in Mr. Rasmussen's discussion. Particularly at velocities of less than 100 ft. per min. the advisability of using the Barth factor is questionable. Also, the velocity is invariably the known factor and should be the base for all plotting or tabulation for reference and use. It should also be pointed out that correct interpolation is not possible in a tabular listing of these values because of the form of the equation. On the other hand, on one 11 x 8½ in. sheet the easily read chart includes a velocity range from zero to 15,000 ft. per min.

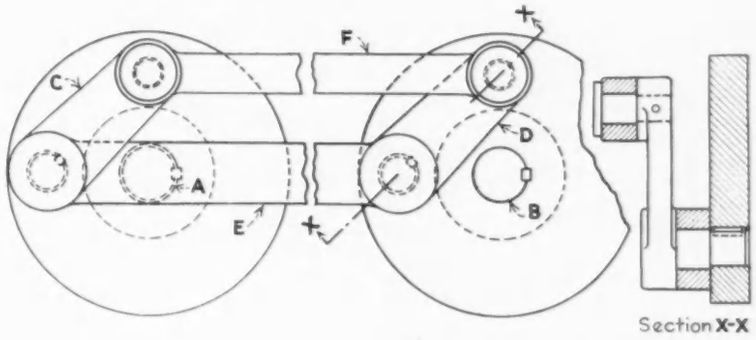
In the enlarged insert, designations for the curves for the factors marked 600 and 3,000 are incorrect. The values should be interchanged.

—FRANK A. MICKLE
University of Michigan

Crank Drives

J. E. FENNO
Belleville, N. J.

● For driving parallel rotating members, cranks are often less expensive than gear or chain drives if the problem of driving through dead center



Double-crank drive has no dead center and a flywheel is not needed

can be solved. In the mechanism shown here, no flywheel is required and the saving in cost over an equivalent gear drive is nearly 75 per cent of the cost of the product.

In this drive a single connecting rod *E* would not permit the drive to function when stalled on dead center, but the second set of cranks *CD*, takes the drive when the first set is on dead center.

Since the relative angular positions of the shafts were required to remain the same, a chain drive could not be considered. In addition to fixing the relative positions of the shafts, the double crank drive is low in cost. There are few bearings, and replaceable bushings can be used for the crank journals.

Also, the use of two sets of rods tends to equalize the torque transmitted, making a fly-wheel unnecessary for this type of drive.

Eight Types of Retaining

Three more examples of screw locks, ten designs

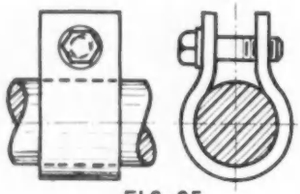


FIG. 25

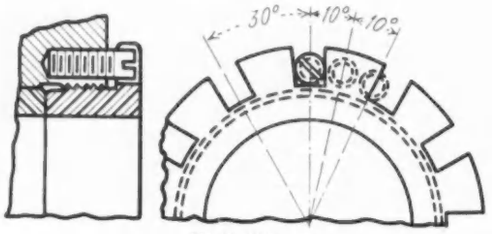


FIG. 26

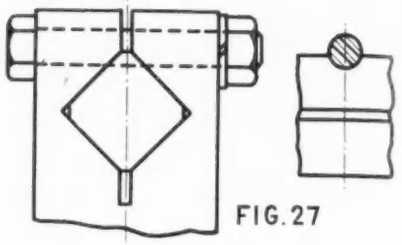


FIG. 27

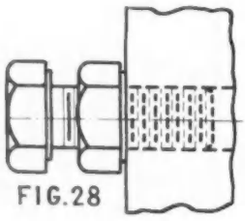


FIG. 28

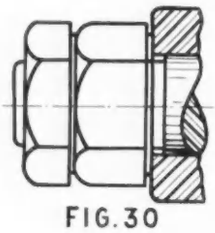


FIG. 30

ADAM FREDERICKS

Fig. 25—A piece of flat stock bent about a shaft may serve the purpose where appearances do not matter.

Fig. 26—Threaded collar with 12 slots 30 deg. apart. Three screw holes 10 deg. apart afford 36 locking positions. With fine thread on nut, close adjustment is secured.

Fig. 27—Member locked on square shaft, the bolt also acts as a longitudinal retainer.

Fig. 28—Hex nut locks screw—wrench needed.

Fig. 29—Knurled nut locks screw—no wrench needed

Fig. 30—Check nut locking standard nut.

Fig. 31—Standard nut locking a check nut. Choice between these methods depends on nature of work.

Fig. 32—Cone pointed screw locked by nut.

Fig. 33—Special faced nut held by formed flat stock, ½ revolution required for locking engagement.

Fig. 34—The tapered nut is split for locking.

Fig. 35—Two opposite units position the threaded rod.

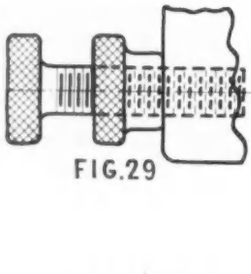


FIG. 29

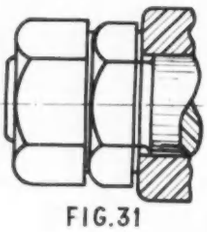


FIG. 31

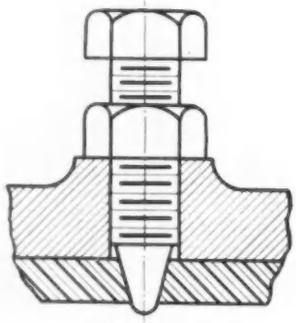


FIG. 32

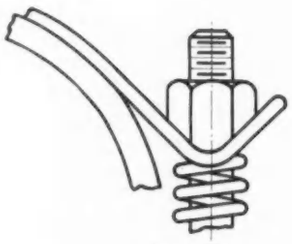


FIG. 33

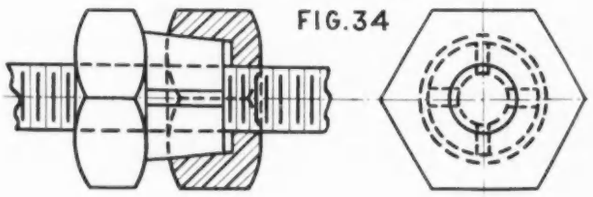


FIG. 34

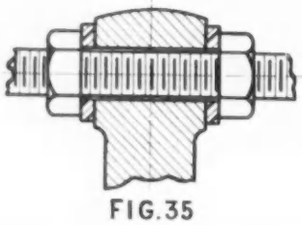


FIG. 35

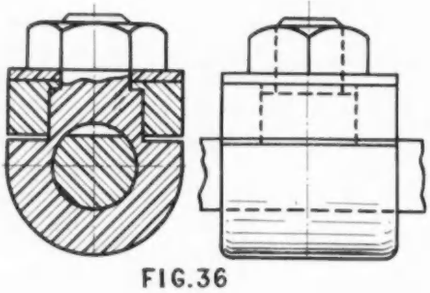


FIG. 36

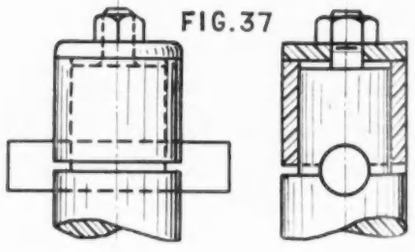


FIG. 37

and Locking Devices—II

of nut locks and eleven washer or key locks

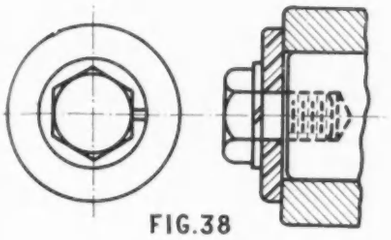


FIG.38

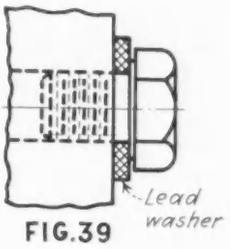


FIG.39

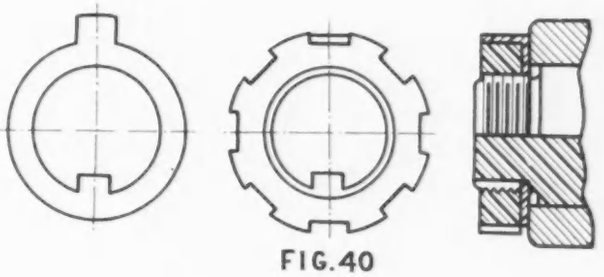


FIG.40

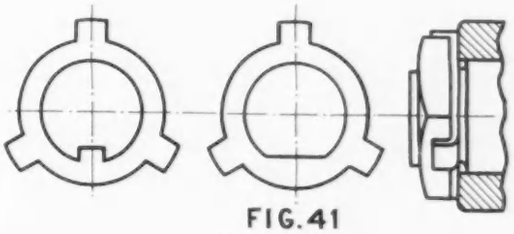


FIG.41

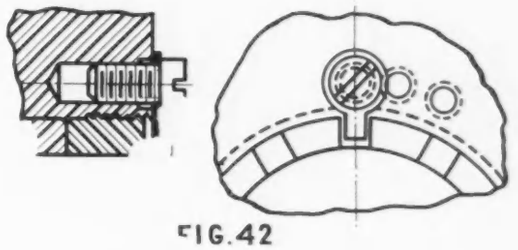


FIG.42

Fig. 36—Similar to Fig. 37 except rod is flattened.

Fig. 37—Rod clamped by sleeve with half round slot milled at lower end.

Fig. 38—One type of common lock washer.

Fig. 39—Washer of lead or soft brass forms lock and seals against oil leakage.

Figs. 40 and 41—Various shapes of washers relying on projections for locking in hole and outside.

Figs. 42 and 43—Similar to Fig. 26 except special key washer and flat stock are used for locking means.

Figs. 44 and 45—Snap washers, the former stiff, the latter of soft material squeezed in place by pliers.

Fig. 46—Two-piece ring against shaft shoulder retained by recess in external chamber.

Fig. 47—Flat stock key for square or hex head screws.

Fig. 48—Lower face of nut milled with 6 grooves engaging 2 humps on washer used with spring. Has 6 positions of locking or adjustment, in one revolution.

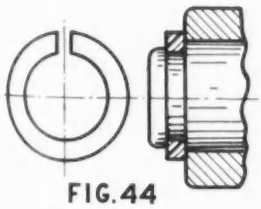


FIG.44

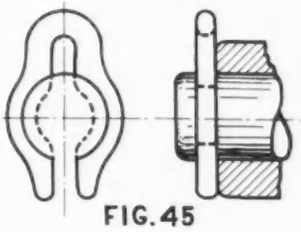


FIG.45

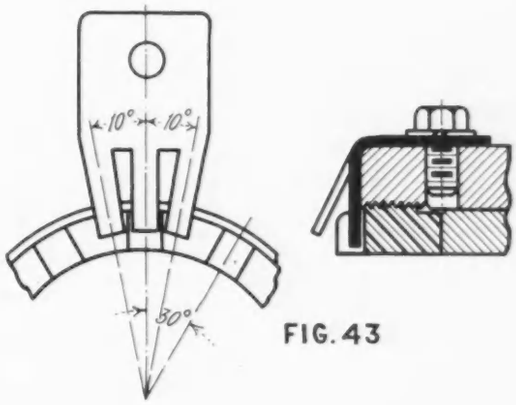


FIG.43

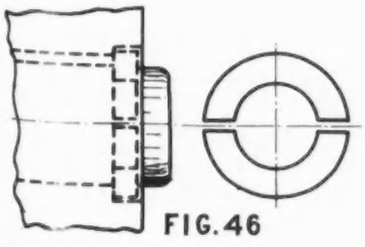


FIG.46

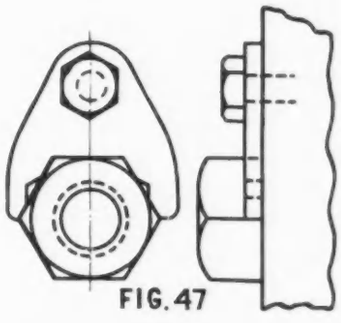


FIG.47

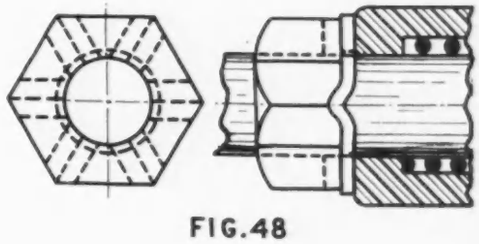


FIG.48

NEWS

Papers and Exhibits at the National Metals Congress

MAKING its first showing in New York, the National Metal Congress will be held during the week of October 1-5 at the Port Authority Building. According to W. H. Eisenman, director of the exposition, the show already is 30 per cent larger than last year's exhibit.

Following the plan used last year, the exhibit will feature demonstrations of manufacturing and fabricating processes. Many exhibitors are planning welding displays showing welding materials, welded products and welding in action. The application and effectiveness of surface finishes will also be demonstrated.

Latest developments in corrosion-resisting, high-strength, heat-resisting and light-weight metals and alloys are being prepared for interesting displays, along with optical, metallurgical and testing equipment.

In addition to displays of engineering alloys and processes, several firms are preparing exhibits of completely fabricated products and parts showing new and unusual applications for deep-drawing steel sheets, castings and forgings, stainless and other alloy steels, welded copper alloys and die-castings.

Design data on die-casting materials and die steels play an important part in the contribution to National Metals Week by the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers. On Wednesday morning, October 3, at the Hotel Pennsylvania papers are scheduled on new aluminum die-casting alloys, die castings of brass, and control of dimensional changes in zinc alloy die castings. An afternoon session will be devoted to the selection of materials and the design of dies for die casting brass and other metals.

Also of interest to designers are several papers scheduled by the American Welding Society at their meeting held during the same week at the Hotel New Yorker. Stress concentration in welds will receive attention in several sessions, reporting results obtained by photoelastic methods, and by fatigue testing. The effect of peening on physical properties, and studies of residual welding stresses will be presented.

Other papers on impact resistance at normal and sub-zero temperatures, corrosion fatigue of stainless steels, hard facing materials and methods of application, and metal spraying processes will also be of interest to designers.

Design Registration Bureau Formed

FORMATION of a design registration bureau has just been announced by the National Alliance of Art and Industry. Operation of this bureau will give, pending effective legislation from Washington, every available protection to original designs submitted by designers or manufacturers.

It has only been recently that active steps have been taken to combat design piracy in the various branches of industry. Of late, recourse to the law has given satisfaction. It is announced that while it is not within the scope of the Alliance of Art and Industry to bring suit against a copyist, the organization can and will ask for an explanation from offenders when piracy has been proved. The organization will also act as a material witness should the case come to trial. It is expected that copyists will hesitate to appropriate designs that have been dated and registered with a recognized organization.

According to the announcement of the National Alliance, design registration will be free to its members, with certain necessary restrictions, while a small charge will be made to non-members.

Calibration Bars for Creep Tests

FOR cross-checking results from different laboratories, a "standard" steel is now available for long-time or creep tests. It is a heat of 0.40 carbon, open-hearth steel that has been specially made, selected, annealed and tested for "calibration bar" purposes.

This steel has been prepared under the direction of the Joint A.S.T.M.-A.S.M.E. Research Committee on Effect of Temperature on the Properties of Metals, in cooperation with the Bethlehem Steel Company. Requests for this steel to be used for cross-checking purposes, along with information as to the amount required, should be sent to M. L. Mochel, Metallurgical Engineer, Westinghouse Electric & Manufacturing Company, Lester Station, Philadelphia, Pa.

Foundrymen to Hear Foreign Papers

DEVELOPMENTS and progress in the castings industry throughout the whole world will be the theme of the Fifth International Congress to be held in conjunction with the 38th Annual Convention and Exposition of the American Foundrymen's Association in Philadelphia, during the week October 22-26.

Modern developments will be presented from three angles: advances in technical knowledge, progress in operating practice, and the latest in the design and improvements in foundry equipment.

A feature of this congress will be the unusual number of papers from foreign foundry groups, Australia, Belgium, Czechoslovakia, England, France, Germany, and Italy contributing papers dealing with modern foundry practice in those countries.

At the joint A.F.A.-A.S.T.M. meeting on tests and specifications, there will be presented papers on high-chromium cast iron, and data on fatigue tests of high-strength iron.

It is expected that the Belgium exchange paper will give data on gray iron which has been collected under

the auspices of the Belgium Research Foundation. This paper should be of great value to both foundrymen and engineers.

A feature of the session on malleable cast iron will be the report of the committee on nomenclature, giving recommendations for names of different products made in malleable foundries.

Featuring the non-ferrous casting session will be a discussion relating to bronze foundry alloys, yellow brass casting alloys and aluminum and its alloys. The problem of porosity in leaded bronze bushings will also be discussed.

Oxide Film Reduces Wear

STEEL surfaces in rubbing contact are given a certain degree of protection by oxide films formed upon them, probably because the film prevents metal-to-metal contact. This is the explanation given in *Research Paper 708*, appearing in the *Journal of Research* for August. When oxide films are absent, severe wear of a galling type is shown to take place, the abraded material being particles of metallic iron. When the contact faces are oxidized, the worn surfaces are smooth, the abraded particles consisting of iron oxides.

Tapered Roller Bearing Standards

ACCORDING to an announcement of the Division of Simplified Practice of the National Bureau of Standards, printed copies of the revised Simplified Practice Recommendation R-67-33 on tapered roller bearings are now available. This current revision of the Simplified Practice Recommendation, originally formulated by the industry in 1927, brings these standards into accord with the Society of Automotive Engineers Revised Standards and extends the scope of the original recommendations to include larger bearings and also certain deep-angle bearings for naval and general use.

Copies of the revised standards on tapered roller bearings can be procured for 5 cents each from the Superintendent of Documents, Government Printing Office, Washington, D. C., or from the office of the American Standards Association, 29 West 39th Street, New York, N. Y.

Chrome-Moly Steel for Creep Resistance

FOR high-temperature service, a chromium steel with 0.5 per cent molybdenum, 0.18 per cent carbon and 4 to 6 per cent chromium is said to possess increased physical properties and greater resistance to creep. As explained by H. C. Cross, metallurgist at the Batelle Memorial Institute, and E. R. Johnson, metallurgical engineer with Republic Steel Corporation, in a paper read before the recent A.S.T.M. convention, impact tests on specimens subjected to load and temperature for 1,000 hours or more revealed no appreciable decrease in toughness.

Better creep properties and more uniform structure in both longitudinal and transverse directions were obtained by slow cooling rather than by normalizing.

MEETINGS

American Foundrymen's Association—Fifth international congress and 38th annual convention, Convention Hall, Philadelphia, Pa., Oct. 22-26. R. E. Kennedy, secretary, 222 W. Adams St., Chicago, Ill.

National Metal Congress — New York, N. Y., Oct. 1-5, the following societies participating:

American Society for Metals—Hotel Pennsylvania, Oct. 1-5. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

American Welding Society—Hotel New Yorker, Oct. 1-5. Miss M. M. Kelly, secretary, 29 West 39th St., New York, N. Y.

American Institute of Mining and Metallurgical Engineers — Institute of Metals Division, Hotel Pennsylvania, Oct. 2-4. John T. Breunich, assistant secretary, 29 West 39th St., New York, N. Y.

EXHIBITIONS

American Foundrymen's Association—Exhibition of foundry equipment, Convention Hall, Philadelphia, Pa., Oct. 22-26. C. E. Hoyt, manager, 222 W. Adams St., Chicago, Ill.

National Metal Exposition—Port Authority Bldg., New York, N. Y. Oct. 1-5. W. H. Eisenman, director, 7016 Euclid Ave., Cleveland, Ohio.

Power Show—11th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York, N. Y., Dec. 3-8. Charles F. Roth, director, Grand Central Palace, New York, N. Y.

Drafting Practice Standards Proposed

A TENTATIVE draft for a proposed American Standard on Drawings and Drafting Room Practice has been issued by the American Standards Association for criticism and comment. Copies of this tentative draft may be borrowed by company members of the American Standards Association.

Sizes of drawings, arrangement of views, line work, dimensioning and lettering are covered in this present draft. The project also includes a standardization for graphical symbols, a tentative draft of which will be presented soon for approval.

The organizations sponsoring this project are the Society for the Promotion of Engineering Education, and the American Society of Mechanical Engineers. The ultimate goal is to establish a recognized and authoritative manual or dictionary which will define standard practice and thereby make it possible for all drawings to be prepared and read easily and accurately. This will eliminate the almost endless variety of graphical symbols and drawing practices as devised by most of the larger drafting rooms for their own use. The proposed standard would serve as a dictionary of drawings.

Babbitt Failures at High Temperatures

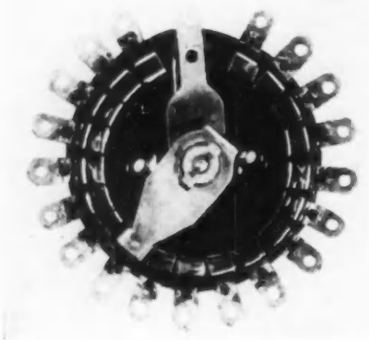
BABBITT bearing failures under high-temperature conditions are not caused by changes in the characteristics of the bearing material. The primary cause of failure is the reduction in the viscosity and amount of lubricant, according to S. W. Sparrow of the Studebaker Corporation, in a paper delivered at a recent meeting of the Society of Automotive Engineers.

From photographs of bearings subjected to various tests, Mr. Sparrow also shows that flexing and faulty bonding are not responsible for cracks in the babbitt. Tangential forces set up by the journal at spots where the oil film is inadequate to prevent metal-to-metal contact are said to be responsible for cracking of the babbitt lining.

New Materials and Parts

Heavy-Duty Tapswitch

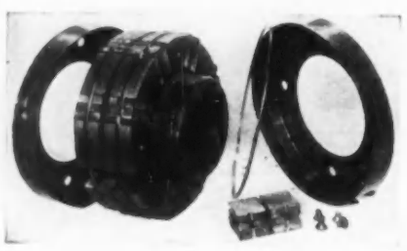
Made from porcelain rheostat parts, heavy-duty switch is of the commutator type in which contact shoe slides over the taps without breaking the



circuit at any point. Since only porcelain and metal are used in the switch, it is said to be adaptable for use under severe weather and temperature conditions. Available also with snap-action between each tap, breaking the circuit between contacts. Ohmite Manufacturing Co., 636 North Albany Ave., Chicago, Ill.

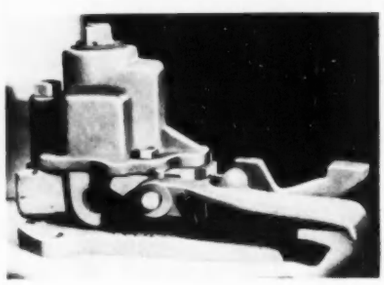
Flexible Couplings

Designated as Type WH, designed for use in connection with gear motors, speed reducers and other industrial drives. Consists of 2 cast steel flanged halves, 2 sheet steel cover plates, 2 snap or retaining rings and from 5 to 22 flexible elements, depending on size. Machined radially around the periphery of each flange are rectangular slots to receive the cushioning and torsionally flexible elements. The torque transmitting element is a rectangular steel plate and the cushioning elements are made from hydraulic packing. In assembly, the torque elements are placed in the center of a slot with a cushioning element on each side. Thus the cushioning elements are subjected only to compression under load. Can be used for speeds up to 8,000 ft. per min. Horsepower ratings are 1.87 to 1,870 hp. per 100 r.p.m. Shaft diameters range from 1 to 10 in., and weight from 6 to 3,115 lb. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



Foot-Operated Valve

Designed for either 3-way or 4-way distribution, the spool moves but $\frac{1}{16}$ in. for a full reversal of fluid flow, the pedal moving through an angle of only 10 deg. Pedal raises only $2\frac{1}{2}$ in. above the floor. Latch combined with the pedal holds it down until unlatched by foot and closed by a spring. Latch may be disconnected by removal of one pin. Valve will then reverse immedi-

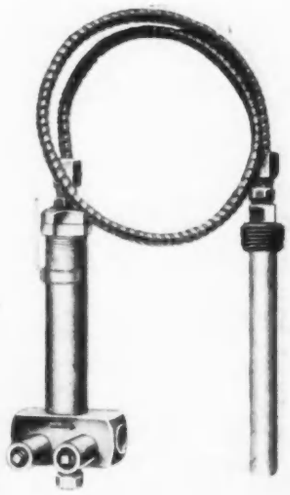


ately when the foot is removed. The principal moving part is a spool or piston, fluid balanced in all directions. Fluid pressure is said to have no effect upon the movement of the spool.

Base plate is large so that valve will not tip when not bolted down. All connection openings are horizontal and near the floor in the base casting of the valve. Cylinder and piston may be removed without breaking connections or disturbing the pedal. Valve is also suitable for automatic operations, requiring only $\frac{1}{16}$ in. straight-line motion. Hanna Engineering Works, 1765 Elston Ave., Chicago, Ill.

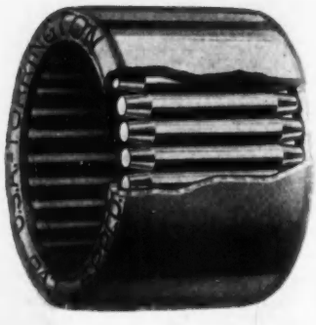
Thermostatic Valves

Actuated by a bellows of one-piece construction for control of temperature and pressure without the use of electricity. Controls have two metering valves arranged for both intermittent and continuous operation. Immersion type illustrated built in two temperature ranges—100 to 180 deg. F., and 200 to 400 deg. F., with a differential of 5 to 10 deg. Standard length of capillary tube is 5 ft. Also available in room temperature ranges with a differential of 2 deg. F., and in pressure control types. Fox Engineering Co., 36 Portland St., Boston, Mass.



Needle Bushing

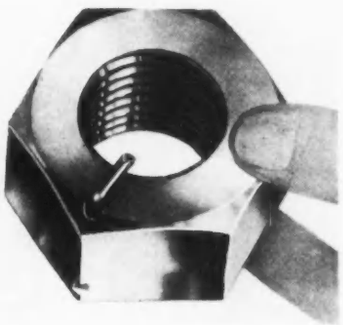
Incorporating the principle of a roller bearing, but occupying no more space than is required for a bronze or babbitt bushing. Consisting of a drawn steel shell with ends turned over to retain a series of needle rollers having tapered ends. Rollers are made from hardened high-carbon steel, centerless ground, the roller diameter being selected to provide a circumferential clearance of 0.0001 in.



between each roll. Lip construction of shell retains rollers without rings or washers, and also supplies a storage capacity for lubricant. For use with shafts hardened to not less than 56 Rockwell C, or shafts with hardened sleeves. Coefficient of friction is said to be less than that of a plain bushing. The Torrington Co., Torrington, Conn.

Automatic Lock Nut

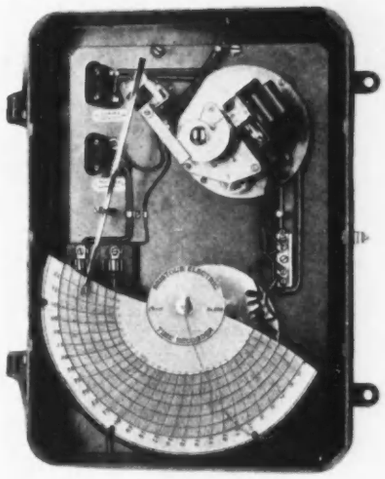
Is a single unit attached or taken off by a wrench in the same manner as an ordinary nut. Claimed to lock and unlock without destroying threads of either the nut or bolt. Nut of standard dimensions has an alloy-steel spring pin which rides the thread when nut is being screwed on. Spring pressure of the pin against the thread



is designed to prevent vibration from loosening the nut. By exerting sufficient pressure with a wrench to throw the pin, point of spring pin is released and nut removed. Claimed that nut can be screwed on and taken off repeatedly without damage to pin, thread, nut or bolt. Automatic Nut Co., Inc., Chrysler Bldg., New York, N.Y.

Operation Recorder

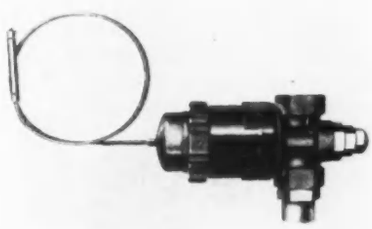
For time-study work, this instrument provides a long record on a fast-moving circular chart. Electric-driven recorder draws in 8 rotations of the chart, a spiral curve starting at the outer edge of the chart and moving in a spiral toward the center. Mechanism records operation of a small electro-magnet which is energized when an external circuit is closed. The movement of the magnet actuates the pen arm, moving the inking pen approximately $\frac{1}{8}$ in. In the illustration, moisture-proof rectangular case and portion of the chart are cut away to show the operating electro-magnet and the spiral cam driven by a separate



synchronous motor. Chart revolves 1 rev. per hr., giving a continuous operation record for a time of 8 hours on one chart. The Bristol Co., Waterbury, Conn.

Refrigerant Valve

A thermostatic valve operated on the expansion principle embodies two bellows working against each other through a stainless steel tierod. One bellows responding to low pressure, closes needle valve. Power bellows connected to a bulb opens the valve only when pressure in the power element exceeds the evaporator pressure. All valve parts subjected to stress and corrosion are made of stainless steel. Needle valve and seat are tipped with special alloy to resist action of refrigerants. Valve is $10\frac{1}{4}$ in. long, furnished with a tube 5 ft.

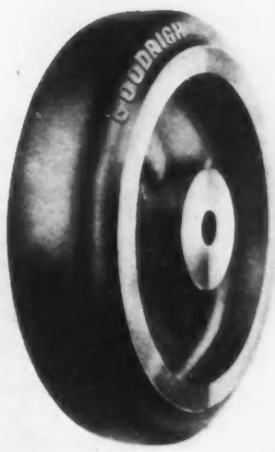


long, factory adjusted for the correct operating pressures for the refrigerant used. Detroit Lubricator Co., Trumbull & Lincoln Sts., Detroit, Mich.

Heat-Resistant Plastic

For electrical insulating applications that require both heat resistance and fine appearance. Designated as No. 1389, the material is a cold-molded compound unaffected by temperatures up to 480 deg. F. Dielectric strength is 120 volts per mil, and transverse strength is 6,000 lb. per sq.in. Compound is practically waterproof. Material is molded to shape at room temperature and heat-treated to impart strength and toughness. For relatively small production quantities, the material is said to result in lower unit cost and reduced mold investment. General Electric Co., Schenectady, N. Y.

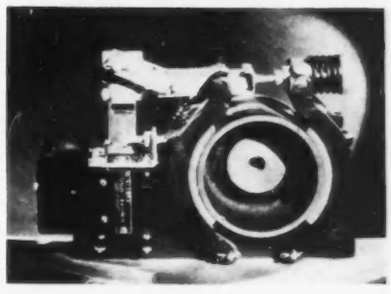
Rubber-Tired Wheels



Rubber tire permanently bonded to the wheel by vulcanizing, using the same process as for solid truck tires. Tread is composed of a special "roller" compound said to provide maximum cushioning to floors and load, rolling easier than a steel tire under ordinary conditions. Available with standard, cage-type, anti-friction roller bearings in one-piece metal wheels with standard lubrication fittings. The B. F. Goodrich Co., Akron, Ohio.

Small Electric Brakes

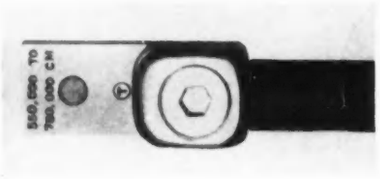
For machine applications where quick, sure stops are required, solenoid-operated brakes incorporate a relatively large brake wheel, allowing low brake shoe pressure distributed over large brake lining areas. Low



unit pressures are said to result in long, even wear of friction surfaces, and to make possible the use of a small operating solenoid requiring less current and imposing lower stresses on pin and pivot joints. Brake shoes use molded brake lining, providing 180 deg. braking surface. Available for a.c. or d.c. in three sizes with torque rating from 3 lb.-ft. to 75 lb.-ft., rated in accordance with N.E.M.A. standards. Dimensions of a.c. and d.c. units are interchangeable. Cutler-Hammer, Inc., Milwaukee, Wis.

Solderless Connectors

Providing definite mechanical and electrical connections, electrical terminals are the same size as regular cast soldering lugs, the connection being made by socket-head screws. Connectors have no projections to reduce electrical clearances. Supplied in eight sizes covering a range of wire sizes from No. 14 to 1,000,000 circular mils. Adjustable feature is said to make each size suitable for a wide



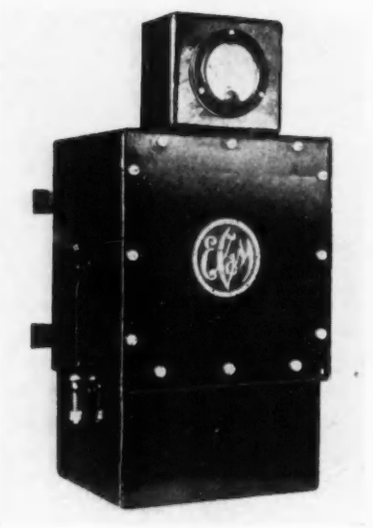
range of wire diameters. Connectors are also said to save time in attaching. Trumbull Electric Mfg. Co., Plainville, Conn.

Plastikon Putty

Similar in appearance and consistency to ordinary painter's putty, mixing is said to be unnecessary because the putty contains practically no oil. Its rubber content is also said to add to its resistance to corrosive chemicals and moisture, and to cause the putty to adhere well to steel surfaces. Supplied in 15, 75 and 225 lb. cans, as well as in pint cans. Sales Promotion Department, Mechanical Division, The B. F. Goodrich Rubber Co., Akron, Ohio.

Weather-Proof Motor Starter

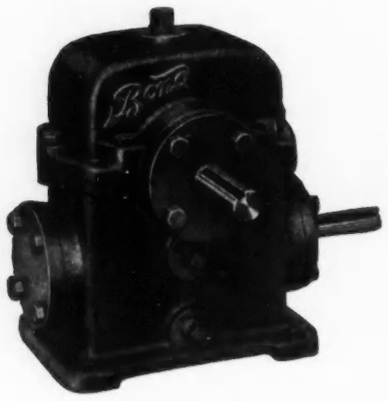
For motors up to 15 hp., 220 volts, and 30 hp. 440-550 volts, motor starter designated as Type ZO is said



to be weather-proof and dust-tight for applications requiring across-the-line, oil-immersed motor control. Starters are inclosed in a case which is bonderized and black enameled. When desired, a self-contained ammeter in a dust-tight case can also be furnished, as illustrated. Starter is arranged for remote push-button operation. The Electric Controller & Mfg. Co., East 79th St. and Woodland Ave., Cleveland, Ohio.

Bond Speed Reducers

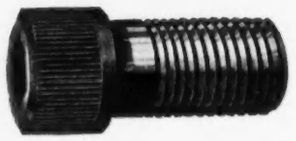
Of the worm-gear type, are available in 21 sizes and in ratios from 5-1 to 2500-1. Inclosed in dust-proof, oil-tight casings. Worm gear is made of gear bronze, worms are of hardened steel with ground threads, integral with high speed shaft. All shafts are mounted on tapered roller bearings and to prevent oil leakage, all shaft openings are provided with oil seals. Available in capacities from $\frac{1}{4}$ to $2\frac{3}{4}$



motor hp. at 1800 r.p.m. Supplied for both horizontal and vertical output shafts. Charles Bond Co., 617 Arch St., Philadelphia, Pa.

Knurled Head Cap Screw

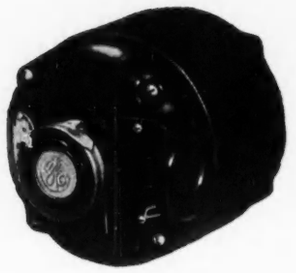
Head is knurled to make hand-driving of screws easier and quicker. Knurling is also said to provide better



grip for pliers, and to improve the appearance in addition to increasing the driving speed. Standard Pressed Steel Co., Jenkintown, Pa.

Washing Machine Motor

Provided with sufficient initial lubricant to last for the lifetime of the domestic washing machine on which the motor is installed. No provision is made for re-oiling. Designated as type KH, this resistance split-phase start, induction-run motor is permanently fixed in a live rubber mounting, treated with a compound impervious to oil to eliminate noise



caused by torque vibration and endwise and radial out-of-balance. Available in ratings of $\frac{1}{8}$ and $\frac{1}{4}$ hp., 110 and 220 volts, 60, 50, and 25 cycles. All $\frac{1}{4}$ hp. motors have the same mounting and overall dimensions, fit into the same space, and mount in the same cradle. General Electric Co., Schenectady, N. Y.

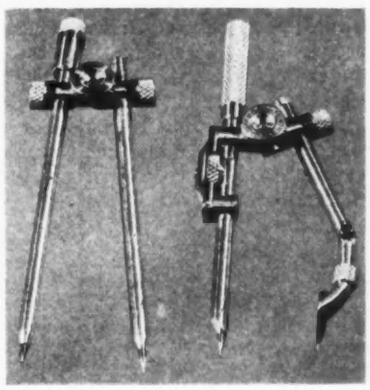
Leaded Bronze Bars

Available in all standard bearing bronze alloys, Permite leaded phosphor bronze bars are said to have free machining properties. Using tungsten carbide tools, material can be machined at speeds in excess of 1500 surface ft. per min., without a coolant, according to the manufacturer. Supplied in standard 6 ft. lengths, in diameters from $\frac{5}{8}$ in. to 2 in. in $\frac{1}{16}$ in. steps. Turned finish is standard for all materials to provide better gripping. Aluminum Industries, Inc., Cincinnati, Ohio.

FOR THE ENGINEERING DEPARTMENT

Drafting Instruments

Consisting of a set of interchangeable parts, from which a number of drafting tools can be assembled as needed. Parts are constructed of aluminum alloy giving light-weight stiff instruments. Parts can be assembled to make a divider (left) or a compass. Eccentric spur provides fine adjustment of the compass. Handle of compass incloses two hardened cone spurs for metal marking. Divider also receives pen or pencil of the compass. Hinge section embodies a friction

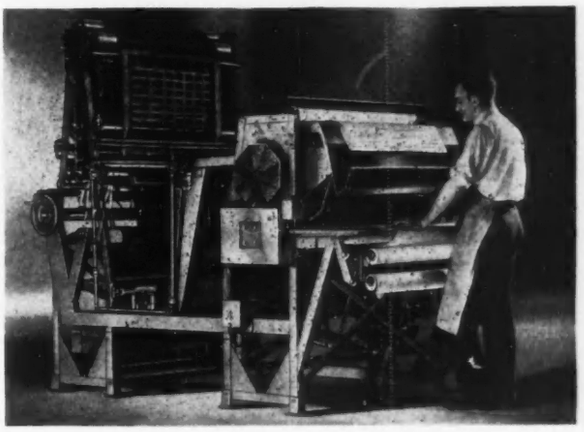


joint, tightened by the large knurled nut. Position of slide on the compass center shaft also adjustable.

Using divider arm as an extension rod gives compass with 10-in. radius, or use of an auxiliary $\frac{1}{8}$ in. rod gives a combination long-arm compass of any radius. Other attachments included with the complete set of parts, also can be combined to make an instrument for drawing an ellipse, or parts can be assembled in the form of a three-point divider. Pen arm for compass can also be used for ruling, a graduated scale being provided on the pen adjustment to indicate the width of the ink line. Complete set of parts supplied in a fiber case. R. B. Ware, 98 Holmes St., North Quincy, Mass.

Blue Printer

Composed of three units, a blueprinting machine, a washing unit, and a potashing and drying unit. Blueprinting machine can be operated independently of the other two units and may be purchased separately. Using



Combined three-unit blueprinting machine announced by Pease

three inclosed arc lamps, set at 17 amp. each, printing speed ranges from 4 in. to 12 ft. per min. An exhaust fan at the left circulates cooling air through the lamp chamber. Resistance coils for the lamps mounted at the back underneath the printer. Gear shift beneath the feed table at the right provides high and low speed, and also disengages the paper drive. Additional speed regulation obtained by a hand-operated dial at the front of the machine, connected by a shaft to a rheostat mounted on the side frame. Oilless bronze bearings are used throughout.

As tracings reach the top of the printer they are returned to a tray at the front of the machine. After exposure, prints on the continuous roll of paper pass through a wash fed by spray tubes, and down into the machine, where a developing solution is applied and washed off. The drying unit combines an electrical heater with a series of rolls, ironing out the paper. The C. F. Pease Co., 813 N. Franklin St., Chicago, Ill.

MANUFACTURERS' PUBLICATIONS

Ball and Roller Bearings—The Bantam Ball Bearing Co., South Bend, Ind. Booklet, 48 pages, 8½x11 in., "Engineering Data," discusses bearing steel, heat-treatment and case hardening practice. Life expectancy, capacity ratings and recommendations for lubrication are included. Bearing closures, shields and mounting are described and illustrated, as well as typical applications for standard and special-purpose bearings. Line drawings show methods for mounting shafts using different types of thrust and floating bearings.

Ball Bearings—The Gwilliam Company, 360 Furman St., Brooklyn, N. Y. Catalog No. 11, 8½x11 in., 16 pages, "Gwilliam Ball and Roller Bearings," giving capacity, dimensions and illustrating ball and roller thrust bearings, special bearings and metal balls.

Belting — E. F. Houghton & Co., 240 West Somerset St., Philadelphia, Pa. Booklet, 16 pages, "The Story of Vim Tred Leather Belting," listing advantages and applications.

Cellulose—Brown Co., Portland, Me. Attractively illustrated 16-page publication, "The Solka Age," devoted to industrial applications of cellulose fiber.

Electric Controls—General Electric Co., Schenectady, N. Y. Booklet, 10 pages. 8 x 10½. "Reduced - Voltage Starters," giving features of construction, data on application and operation for auto-transformer type controls for squirrel-cage induction motors.

Instruments — The Brown Instrument Co., Philadelphia, Pa. Catalog No. 6501, 8½x11 in., 28 pages, "Brown Hygrometers for Recording and Controlling Humidity," describes applications and construction details of several types. Booklet includes a 2-page relative humidity table.

Keys—The Whitney Manufacturing Co., Hartford, Conn. Booklet, 8 pages, including profile and key dimensions for Woodruff type keys.

Lubricants—Acheson Colloids Corp., Port Huron, Mich. Bulletin No. 182, 4 pages, gives a report of tests conducted at the National Physical Laboratory of a ball-bearing lubricated with graphited oil.

Optical Instruments — Bausch & Lomb Optical Co., Rochester, N. Y. Booklet, 24 pages "Research Microscopes" describing instruments, lenses and accessories.

Packing — Johns-Manville, 22 East 40th St., New York, N. Y. Booklet, 7½x10 in., 48 pages, "Johns-Manville Packings," with engineering data on packing recommendations for braided

asbestos, asbestos cloth, semi-metallic, and other types for various industrial applications.

Plastics—Synthane Corp., Oaks, Pa. Sample book including actual samples of five grades of laminated plastics with physical properties, and electrical characteristics.

Plastics—Tennessee Eastman Corp., Kingsport, Tenn. Second edition of "Tenite," 40 pages, describing a thermoplastic molding material made from cellulose acetate. Uses, forms, molding procedure, machineability, mold design and physical qualities are included.

Relays—Eagle Signal Corp., Moline, Ill., Bulletin No. 233, 4 pages containing wiring diagrams, ratings and catalog information on ten types of relays.

Roller Bearings — Shafer Bearing Corp., 6501 West Grand Ave., Chicago, Ill. Catalog No. 12, 8½x11 in., 50 pages, "Shafer Roller Bearings," describing features of a self-aligning type for combined radial and thrust loads. Types, applications, specifications, load ratings, and service modifying factors are included for medium and standard duty units in pillow blocks, flange mountings, hanger boxes, cartridge units and single roll types.

Rheostats — Ohmite Manufacturing Co., 636 N. Albany Ave., Chicago, Ill. Catalog No. 10, 8 pages, "Ohmite Rheostat and Resistance Units," with information on vitreous enameled rheostats and resistors.

Rheostats—Ward Leonard Electric Co., Mount Vernon, N. Y., Bulletin No. 2501, four pages, with catalog information and application data on battery charging rheostats and resistors.

Testing Equipment—Baldwin-Southwark Corp., Philadelphia, Pa. Bulletin No. 73, 8½x11 in., 32 pages, "McCollum-Peters Electric Telemeter," describing a carbon-resistor telemeter for measuring load deflections and amplitudes of vibration. Principle of operation and many applications described and illustrated.

V-Belts — The Manhattan Rubber Mfg. Division, Passaic, N. J. Data book, 56 pages, 8½x11, "Condor V-Belts, Engineering Data Book." In addition to catalog information on belts and sheaves, information is included on selection and design of V-Belts and V-Flat Drives.

BOOKS AND BULLETINS

Kinematics of Machines

G. L. Guillet. 272 pages, 5½x8½ in. Well illustrated. Red clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $3.

Some rearrangement of text and additional problems are embodied in the third edition of this book written primarily for class-room use.

Prepared for students having had one year of college work in mathematics and physics, the book is confined in scope to the usual engineering course in kinematics. Although text and problems both have a strong textbook flavor, problems and illustrations are for the most part drawn from practical engineering designs.

Each chapter opens with definitions and classifications of motions and closes with a series of problems. Chapter headings include instant centers, plane motion, cam mechanisms, rolling contact and gearing. At the end of the text is a series of 35 drafting room problems and an index.

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Machine Drawing

Eliot F. Tozer and Harry A. Rising. 311 pages, 6x9 in. Illustrated. Clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.

In presenting their subject, the authors assume that the student is well grounded in the theory of projection, this phase of the subject being entirely omitted from the book. The stated aim of the book is to acquaint the student with the requirements and nomenclature for mechanical drawing, preparatory to a course in machine design.

Only three chapters of the book deal directly with the general drawing room practice. These comprise chapters on principles and materials of drawing, general drafting-room practice and the dimensioning of drawings. The other fourteen chapters are devoted to methods and material of machine production, engineering data and drafting room practice relative to machine elements such as fastenings, bearings, belts and pulleys, gears and similar elements. There is one chapter on machine sketching and another chapter containing 177 problems. An appendix of 2½ pages gives a bibliography of shop terms in general use.

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Plastic Molding

Louis F. Rahm, 246 pages, 6x9 in. 77 illustrations. Blue clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.

In bringing together up-to-the-minute data on plastics, molds and equipment, the author has prepared a complete yet concise reference book for designing engineers.

Part I, of most value to designers, describes the molding process and the plastics, including tables of properties for each of eight molding compounds. These tables are complete, giving physical constants, electrical characteristics, effect of moisture, acids and solvents, colors available, and machining qualities. Typical molded products are illustrated.

In Part II, factors entering into the selection of the type of mold are explained with reference to the shape of the molded part, dimensional tolerances, quantity and type of plastic. Design details for individual dies and die plates, and a chapter on die hobbing close this section.

Parts III and IV describe operating equipment and plant layout. An appendix of 35 pages lists tradenames of plastic products.

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Dissipation Constants in Solids

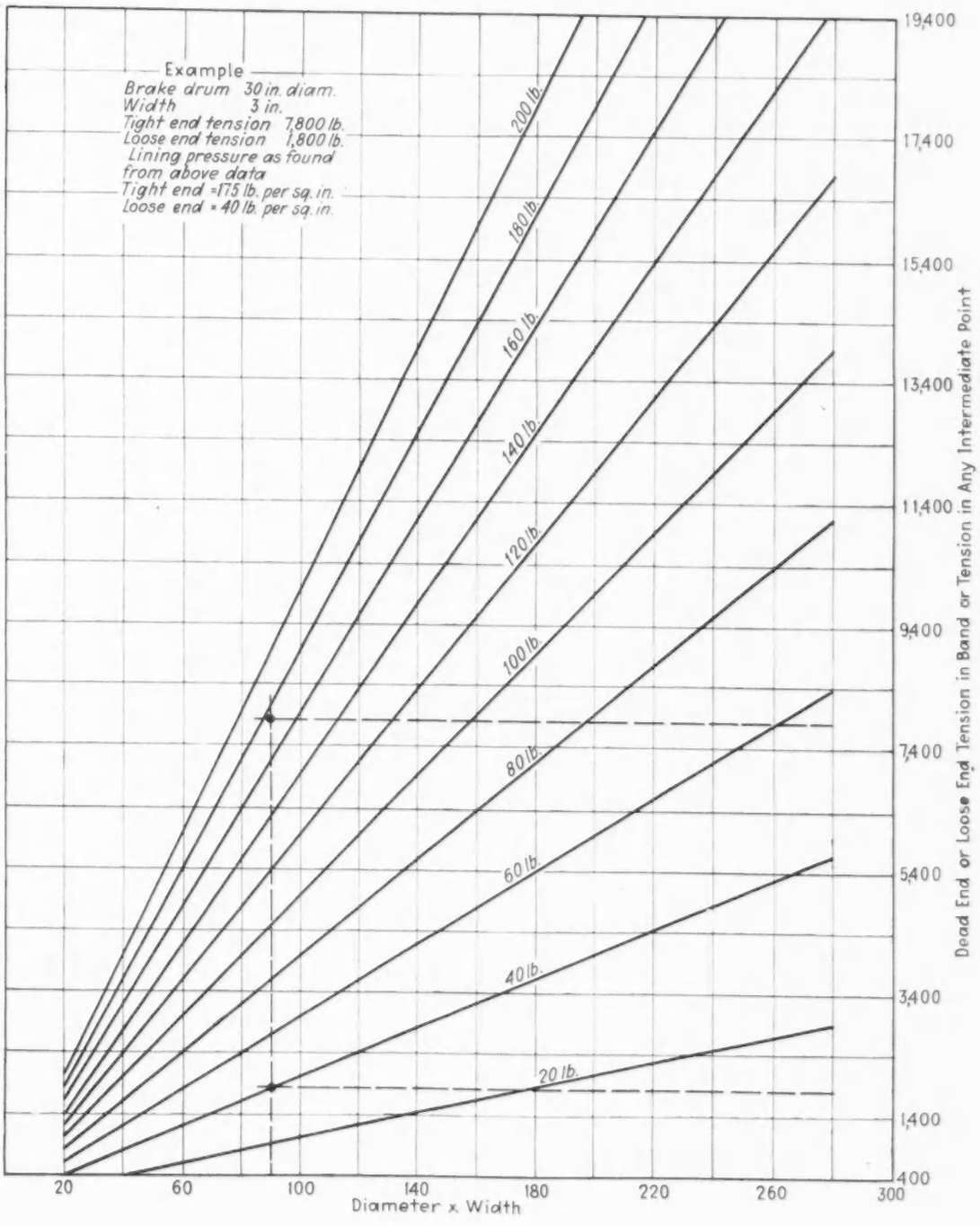
Bell Laboratories Record, August 1934, pages 363-366, by H. Walther. Measurement of internal friction or viscosity in a number of engineering materials show a wide range of damping coefficients which apparently bear no relation to other physical properties. The author suggests that this damping coefficient may furnish a means for measuring different states of internal strain or structure.

The Strength of Screw Threads Under Repeated Tension

University of Illinois *Engineering Experiment Station, Bulletin No. 264,* by H. F. Moore and P. E. Henwood, 18 pages, 25 cents. Stresses in U. S. Standard, and Whitworth threads in medium-carbon steel and heat-treated S.A.E. 2320 nickel steel, and rolled threads in medium-carbon steel were obtained from endurance tests. Stress concentration factors were determined as the ratio of the endurance limit of the metal to the endurance limit of the threaded specimens. Higher factors were found for the nickel steel material, and for the U. S. Standard thread. Safe working stresses are suggested for these materials.

Lining Pressure for Known Tensions in Clutch Bands

R. H. LEWIS



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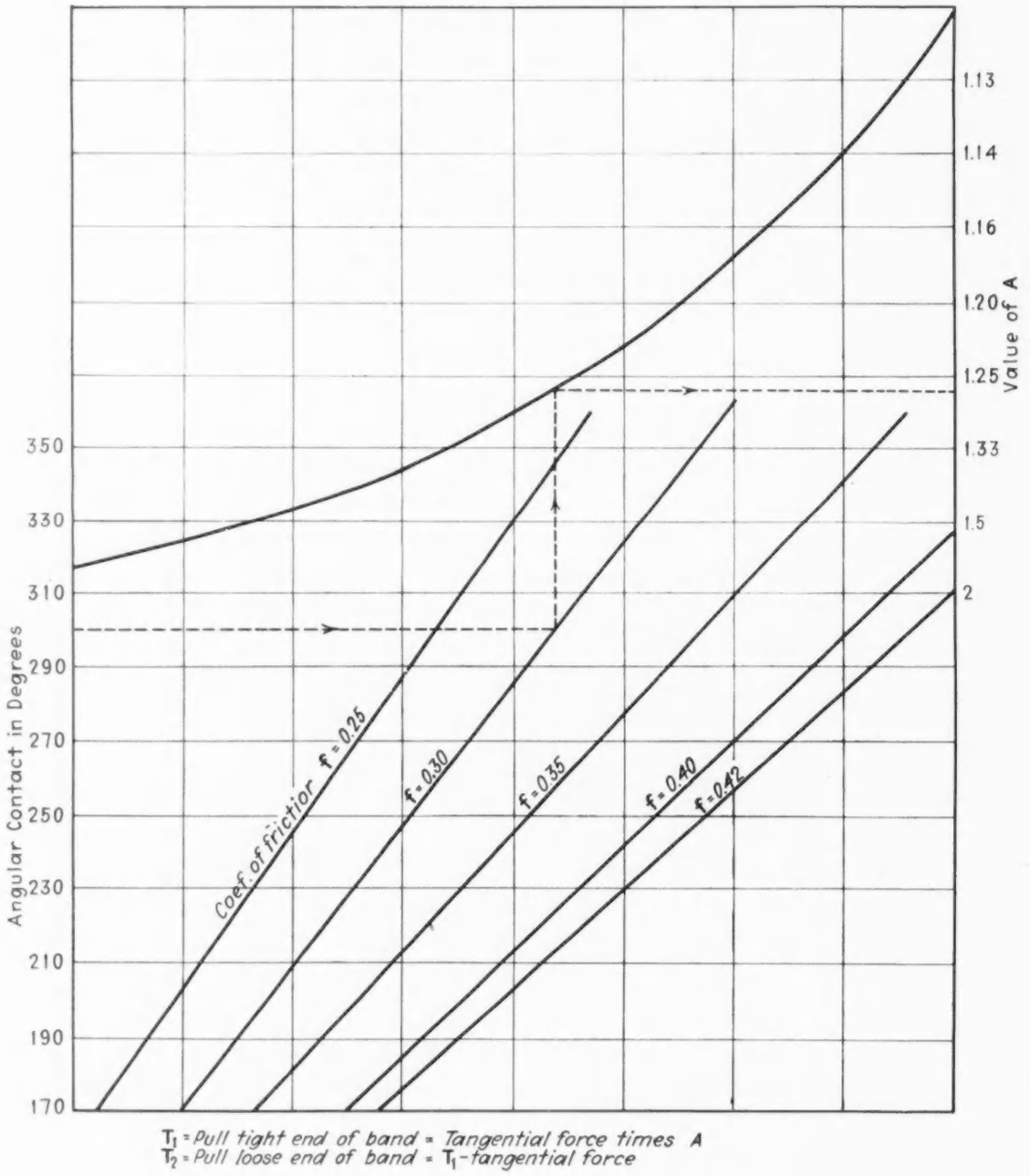
Pull at Tight End of Clutch Bands

R. H. LEWIS



T_1 = Pull tight end of band = Tangential force times A
T_2 = Pull loose end of band = T_1 - tangential force

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